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Electrical Wires and Cables

Catalogue and Handbook

American Steel & Wire Company.

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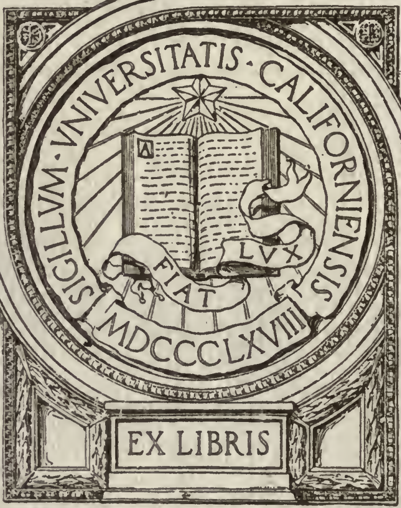
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Electrical Wires and Cables

Errata

Page 21. Title underneath illustration should read Micrometer ***Calipers.***

Page 54. Diameter 1 has been omitted in first column of first table.

Page 56. Fourth line should read 980 ***cm.*** per second.

Page 80. Fourth line from bottom should read ***rope*** wire instead of piano wire.

Page 100. Each of last 5 lines of 8th and 16th columns should read ***pounds*** instead of feet.

Page 114. Second line from top should read No. 32 B. & S. instead of No. 31.

Page 145. Second paragraph, first line, 145 should read page 144.

Page 164. Title under first illustration should read ***served*** in place of sewed.

Page 165. Second line should read "taped ***over all.***"

Page 178. In first column of table, list number opposite 1/0 should read 252 S instead of 250 S.

Page 56. Under caption ***Electrical Data,*** equations should read as follows:

The ampere $= 10^{-1}$ cm.$^{\frac{1}{2}}$ g.$^{\frac{1}{2}}$ sec.$^{-1}$
" ohm $= 10^{9}$ cm. sec.$^{-1}$
" volt $= 10^{8}$ cm.$^{\frac{3}{2}}$ g.$^{\frac{1}{2}}$ sec.$^{-2}$
" henry $= 10^{9}$ cm.
" farad $= 10^{-9}$ cm.$^{-1}$ sec.^{2}

Electrical Wires and Cables

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United States Steel Products Company
30 Church Street, New York, N. Y.

Catalogue and Handbook

of

Electrical Wires and Cables

UNIV. OF
CALIFORNIA

American Steel & Wire Company

Chicago New York Worcester
Denver San Francisco

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American Steel and Wire Company

Preface

THIS Catalogue-Handbook presents in serviceable form information interesting to customers, engineers and students. All types of bare and insulated electrical wires and cables now in common use are fully described herein. A considerable amount of engineering data and descriptive matter, including an abridged dictionary of electrical terms, has been introduced for the purpose of making the book a fairly complete treatise on electrical conductors.

Much of the information may be found in books of reference, but some of it is published here for the first time. The data have been carefully compiled and arranged with a view of rendering the customer all possible assistance in selecting and specifying the material best suited to his requirements.

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Contents

THIS book conveniently and logically divides into nine sections, the first of which contains in descriptive and tabulated form general engineering data relating to copper, iron and aluminum electrical conductors.

PAGE
GENERAL DATA 11

The following seven sections constitute the catalogue portion of the book, in which is given not only a complete list of all bare and insulated electrical wires and cables manufactured by this company, but also some general information regarding standard specifications and the uses and construction of conductors.

PAGE
BARE WIRES AND CABLES . . . 57
MAGNET WIRE 83
ANNUNCIATOR AND OFFICE WIRES . 93
WEATHERPROOF WIRES AND CABLES . 97
LAMP CORD PRODUCTS . . . 107
RUBBER-COVERED WIRES AND CABLES 115
LEAD ENCASED WIRES AND CABLES AND THEIR INSTALLATION 147

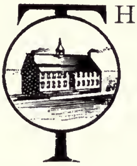
The final section has been compiled with considerable care for use as a dictionary of electrical terms.

PAGE
ABRIDGED ELECTRICAL DICTIONARY OF COMMON WORDS, TERMS AND PHRASES 183

The book concludes with a very complete index, having conveniently arranged cross references to materials used specially for electric light, electric railway and telephone and telegraph work.

PAGE
INDEX 229

Facilities



THE first electrical wire factory of the American Steel and Wire Company, established in 1834, is here represented. In this and in later buildings, the most important improvements in the manufacturing of all kinds of wire were invented and adopted. The business and the plant have developed rapidly. About twenty years ago preparations were made for producing our first insulated electrical wire. Shortly after this the first enlarged terminal stud rail bonds were made in these works. Since that date vast changes and advances have taken place in every branch of electrical engineering, and these have been accompanied by a corresponding growth in our manufacturing facilities.

Reinforcing our extensive factory equipment, there are well equipped chemical, physical and electrical laboratories, wherein the problems incident to the solution of every difficulty encountered are handled by thoroughly reliable experts and up-to-date methods. All steel and copper used by us is rolled and drawn in our own mills and under our own supervision throughout every operation. All raw materials are tested and inspected before being used, the manufacturing processes are constantly checked, and finally the finished material is subjected to an exhaustive series of tests that determine beyond question whether or not it is of proper quality. With such facilities at our disposal we are enabled to manufacture electrical conductors of all kinds to the severest specifications, and to give to the users of our product a standard of quality that is unexcelled.

Regarding Orders

IN order to avoid errors, delays and misunderstandings, purchasers should carefully note the following:

1. Orders and correspondence regarding orders should always be sent to the nearest sales office, list of which is given on page 4.

2. Describe fully material ordered. List numbers are provided in this catalogue to facilitate ordering.

3. When referring to orders always give the number or date of the order.

4. State distinctly how goods are to be shipped, whether by freight, express or mail. If any special route is preferred it should be mentioned in the order. We reserve the right to route all shipments upon which we pay or allow freight.

5. Before returning reels or other material, please secure from us shipping directions.

6. No claims for allowances will be entertained unless made within ten days after arrival of the goods, and no allowance will be made beyond the original invoice price of material.

7. All prices are subject to change without notice.

8. All agreements are contingent upon strikes, accidents or other causes beyond our control.

General Data

Page
Conductance and Resistance 12
Physical Properties of Conductors 14
Temperature Effects on Resistance 15
Carrying Capacities of Conductors 18
Resistance of Copper at Different Temperatures and Conductivities 17-19
Alternating Current Heating Effects 19
Measurements of Wires, Wire Gauges . . . 21
Comparative Table of Wire Gauges 22
Wiring Formulae and Tables 22-26
Strands 27
    Concentric Cables 32
    Rope Strands 32
The Manufacture of Wire 35
    Copper 35
    Iron and Steel 39
    Wire Drawing 42
    Tinning and Galvanizing Wire 44
Packing and Shipping 44
    Coils 45
    Reels 49-50
Miscellaneous Tabulated Data 52-56

General Data

Conductance and Resistance

ELECTRICAL energy is always transferred from the generating source to the receiving device through, or by means of, some form of *conductor*. This is one of the three necessary parts of any electrical circuit. With the various kinds of metallic conductors we shall be chiefly concerned in this catalogue.

Electricity may be transmitted through any substance, though in widely varying degrees. The following table gives a list of materials which are arranged approximately in order of their conducting powers :

Conductors	Non-Conductors or Insulators	
All metals	Dry air	Ebonite
Well-burned charcoal	Shellac	Gutta-percha
Plumbago	Paraffin	India rubber
Acid solutions	Resins	Silk
Metallic ores	Sulphur	Dry paper
Living vegetable substances	Wax	Dry leather
Moist earth	Glass	Porcelain
Water	Mica	Oils

The conducting power of any substance depends largely upon its physical state. For instance, the conductivity of air decreases very rapidly as its pressure increases, while rarefied air makes a good conductor of electricity. The conductivity of all substances materially alters with change of temperature.

The number of substances which are used for conductors of electricity in commercial work is, however, limited to three of the useful metals, copper, iron and aluminum. Of these, the first is pre-eminently the best, while next in order come aluminum and iron. Pure copper possesses many physical properties of great engineering value in addition to that of its high conductivity. It has to a very high degree the qualities of malleability and ductility which make it an ideal metal for wire drawing. Its strength and hardness are greater than that of any other metal except iron and steel. It has the power of resisting oxidation, it takes a fine polish, is easily worked, and can be forged more easily than iron.

The precious metals, platinum, gold and silver, are used as conductors only to a limited extent in laboratories and for scientific purposes. A list of the common metals, arranged in order of their relative conducting properties, is given in the following table :

Relative Conductivity of Pure Metals

(Matthiessen's Standard)

Metals	Relative Conductivity	Metals	Relative Conductivity
Silver, annealed	108	Iron, wrought	17.6
Copper, annealed	102	Nickel	13.0
Gold, annealed	73	Tin	12 0
Aluminum, annealed	63	Lead	8.0
Zinc	28	Mercury	1.7

General Data

Since the conductivity of any one wire will in general differ from that of any other, it becomes necessary in comparing or specifying wires to refer to some standard or system of units. We cannot describe anything except by comparing it with some standard which is recognized by and familiar to all. The conducting power of a substance is usually expressed in terms of its electric *resistance* rather than in terms of conductivity. The resistance of a wire is the reciprocal of its conductivity. A wire that is high in conductivity is low in resistance and vice versa. Resistance is that property of a conductor by virtue of its form and molecular structure which modifies the strength of current flowing through it. It is an inherent property of all electrical conductors; even the best conductors possess appreciable resistance.

The commercial standard of conductivity in this country is the one established by Dr. Matthiessen in 1861. It is that of a piece of supposedly pure copper wire of constant cross-section having the following specifications:

Specific gravity, 8.89.
Length, 1 meter or 39.3704 inches.
Weight, 1 gram or 15.432 grains.
Resistance, 0.141729 ohms at 0° C.
Specific resistance, 1.594 microhms per cubic centimeter, or
Specific resistance, 0.6276 microhms per cubic inch at 0° C

Much of the copper now being made is higher in conductivity than Dr. Matthiessen's standard by one or two per cent., owing to improved methods of refining copper. It is usual, however, to specify that soft drawn copper shall have 98 per cent. conductivity and hard drawn copper 97 per cent. of Matthiessen's standard.

The practical unit of resistance is the *International Ohm*, which is the resistance offered to an unvarying electric current by a column of pure mercury at a temperature of melting ice, 14.4521 grams (0.51 ounces) in mass, of a constant cross-sectional area, and 106.3 centimeters (41.85 inches) in length. To obtain a concrete idea of this unit it may be remembered that a copper wire having a diameter of one tenth of an inch, has at 68° F. a resistance of approximately one ohm per thousand feet, or 5.28 ohms per mile.

Resistance varies greatly with different metals and is in general less for a pure metal than for any of its alloys. Its value will in every case depend upon the relation of three factors. The length of the wire, its cross-sectional area, and the nature or chemical composition of the metal, all of which vary with temperature. Increasing or decreasing the length (L) of any conductor will increase or decrease the resistance (R) of the conductor in direct proportion. Increasing or decreasing its sectional area (A) will inversely affect its resistance, that is, as the section of the conductor increases the resistance becomes proportionately less, and conversely. The term conductor as used in this connection should be taken in its broadest sense, meaning the whole length of any circuit or any portion of a circuit under consideration, whether it be in a straight line or wound in a coil.

For example: One mile of any given wire will have twice the resistance of one-half mile of the same wire, or 5.28 times the resistance of 1,000 feet. Again, if we have two wires of equal length, one of which has a sectional area five times as great as that of the other, then, assuming uniform quality and treatment, the electrical resistance of the larger wire will be one-fifth that of the smaller, and as the

General Data

weight per unit length varies directly as the sectional area, it follows that the resistance of a wire weighing, for example, 500 pounds per mile, will equal one-fifth the resistance of a wire weighing 100 pounds per mile, assuming uniform quality and treatment as before.

Algebraically, these relations may be expressed thus:

$$R = K\frac{L}{A}$$

Where (K) is a constant for any metal and represents its *resistivity* or *specific resistance.*

Resistivity, a factor depending only on the material or structure of the metal as compared with pure copper as unity, may be expressed in a number of different ways, all being equivalent to the resistance of some unit of cross-section. This unit may be expressed either in linear dimensions or as a combination of weight and dimensions. It may represent the resistance measured between opposite faces of a unit cube of the metal. Or, another and more common way of expressing resis-

Physical Properties of Copper, Aluminum, Iron and Steel Wire

Physical Properties		Copper		Aluminum 99 Per Cent. Pure	Iron (Ex. B. B.)	Steel (Siemens Martin)
		Annealed	Hard Drawn			
Conductivity, Matthiessen's standard		99 to 102	96 to 99	61 to 63	16.8	8.7
Ohms per mil-foot at 68° F. = 20° C. (K)		10.36	10.57	16.7	62.9	119.7
Ohms per mile at 68° F. = 20° C.		$\frac{54{,}600}{\text{cir. mils}}$	$\frac{55{,}700}{\text{cir. mils}}$	$\frac{88{,}200}{\text{cir. mils}}$	$\frac{332{,}000}{\text{cir. mils}}$	$\frac{632{,}000}{\text{cir. mils}}$
Pounds per mile-ohm at 68° F. = 20° C.		875	896	424.0	4700	8900
Temperature co-efficient per degrees F. Mean values		.00233	.00233	.0022	.0028	. . .
Temperature co-efficient per degrees C. Mean values		.0042	.0042	.0040	.0050	. . .
Specific gravity. Mean values		8.89	8.94	2.68	7.77	7.85
Pounds per 1,000 feet per circular mil.		.003027	.003049	.000909	.002652	.002671
Weight, in pounds per cubic inch		.320	.322	.0967	.282	.283
Specific heat. Mean values		.093	.093	.214	.113	.117
Melting point in degrees F. Mean values		2012	2012	1157	2975	2480
Melting point in degrees C. Mean values		1100	1100	625	1635	1360
Mean co-efficient of linear expansion. Degrees F.		.00000950	.00000950	.00001285	.00000673	.00000662
Mean co-efficient of linear expansion. Degrees C.		.0000171	.0000171	.0000231	.000120	.000118
SOLID WIRE Pounds per square inch	Tensile strength	30,000 to 42,000	45,000 to 68,000	20,000 to 35,000	50,000 to 55,000	100,000 to 120,000
	Elastic limit	6,000 to 16,000	25,000 to 45,000	14,000	25,000 to 30,000	50,000 to 72,000
	Modulus of elasticity	7,000,000 to 17,000,000	13,000,000 to 18,000,000	10,500,000 to 11,500,000	22,000,000 to 27,000,000	22,000,000 to 27,000,000
CONCENTRIC STRAND Pounds per square inch	Tensile strength	29,000 to 37,000	43,000 to 65,000	25,800	. . .	98,000 to 118,000
	Elastic limit	5,800 to 14,800	23,000 to 42,000	13,800	. . .	45,000 to 55,000
	Modulus of elasticity	5,000,000 to 12,000,000	12,000,000 to 14,000,000	Approx. 10,000,000	. . .	16,000,000 to 22,000,000

General Data

tivity is in terms of *ohms per mil-foot*, meaning the resistance of a round wire one foot long, having a diameter of one mil or .001 inch and an area of one circular mil. With this unit, the resistance of any wire is found by multiplying its length (L) by its resistivity (K see page 14) in ohms per mil-foot and dividing this product by the section area expressed in circular mils.

For telephone and telegraph conductors it is customary to use still another unit of resistivity—*weight per mile-ohm*. This is the weight of a conductor one mile in length, which has a resistance of one ohm. It equals the product of the resistance per mile and the weight per mile. However great may be the variation in weight of wires of different sizes, the variation in resistance is equally great inversely, and so the balance is preserved.

To illustrate: If the mile-ohm be 5,000, the resistance of a wire weighing 1,000 pounds per mile will be 5 ohms, while a similar wire weighing 5 pounds per mile will have a resistance of 1,000 ohms. This method of expressing resistance is more direct than the others, which require interpretation before the results may be used in any calculation. Values for these various units will be found tabulated on page 14.

Temperature Effects on Resistance

The question of temperature bears an important part in all tests and calculations of electrical conductors, as the resistance varies directly with temperature. The resistance of copper wire increases about twenty-three one-hundredths and that of iron wire about twenty-eight one-hundredths per cent. for each additional degree F.

Dr. Matthiessen, while experimenting with copper conductors, derived the following formula for the change of resistance with temperature in copper wire:

$$R=R_0(1+.00387t+.0000059t^2)$$

Later experiments have shown that for practical engineering purposes all terms below the second may be dropped, and that the above equation for temperature changes in copper wire may now be written:

$R_t=R_0(1+.0042t)$ for t in degrees C. or

$R_t=R_0(1+.0023t)$ for t in degrees F.

Where R_0 = Resistance at 0° C.

R_t = Resistance at any temperature t°

The general equation for any conductor is usually written:

$R_t=R_0(1+a\,t)$, where

a is called the *temperature coefficient* of the conductor. These coefficients vary considerably with the purity of metals, and they change slightly even in the purest metals. The following average values of the temperature coefficient have been found experimentally, at 0° C.

Metals	Centigrade	Fahrenheit
Aluminum	.0040	.0022
Copper, annealed	.0042	.0023
Gold	.0038	.0021
Mercury	.0007	.0004
Platinum	.0025	.0014
Silver, annealed	.0040	.0022
Soft iron	.0050	.0028
Tin	.0044	.0025
Zinc	.0041	.0023

For convenience in determining the resistivity of copper conductors at various temperatures, we give on page 17 the resistance per mil-foot at temperatures

General Data

ranging from $-10°$ C. to $45°$C. at 97 per cent., 98 per cent. and at 100 per cent. conductivity Matthiessen's standard. We also give, on page 19, the weight per mile-ohm at various temperatures and conductivities within practical limits.

If a continuous current of electricity flows through any conductor, a certain definite portion of the electrical energy supplied to the conductor will be required to overcome its resistance and transmit the current between any two points in the conductor. This energy of transmission, as it is called, is never lost, but is transformed into heat energy. Heat will be developed whenever any electric current flows through any conductor, or part of conductor, the amount of heat being directly proportional to the resistance of the conductor and to the square of the current flowing. The amount of heat measured in calories will equal

$$H=0.24\ I^2R\ t$$

Where H represents calories of heat produced
I " current in amperes
R " resistance of conductor in ohms, and
t " time in seconds that the current flows.

If heat be developed in the conductor faster than it can be dissipated from the surface by radiation and convection the temperature will rise. The allowable safe temperature rise is one of the limiting features of the current carrying capacity of any conductor. Since the rate at which heat will be dissipated from any conductor will depend upon many conditions, such as its size and structure, the kind and amount of insulation, if any, and its location with respect to other bodies, it is not possible to give any general definite rule for carrying capacity that will be true for all conditions. The following empirical formula* will give approximate values for the current I flowing through a solid conductor, or through *each conductor* of a multiple conductor cable which will cause a rise in temperature of t degrees C.

$$I=C\sqrt{t\ \frac{d^3}{K}}$$

In this, d represents the diameter of the bare wire or strand, K is the resistance per mil-foot of the wire at allowable elevated temperature t taken from the curves given on next page, and C is a constant having the following values for different conditions.

Location and Kind of Conductor	Values of Constant C in Expression $C\sqrt{t\frac{d^3}{K}}$	
	Solid Conductor	Stranded Conductor
Bare overhead wires out of doors	1250	1100
Bare wires in doors, exposed	660	610
Single conductor rubber covered cable in still air . .	530	490
Single conductor rubber covered lead sheathed cable in underground single duct conduit	530	490
Single conductor paper covered lead sheathed cable in underground single duct conduit	470	430
Three-conductor rubber covered lead sheathed cable in underground single duct conduit	400	370
Three-conductor paper covered lead sheathed cable in underground single duct conduit	350	320

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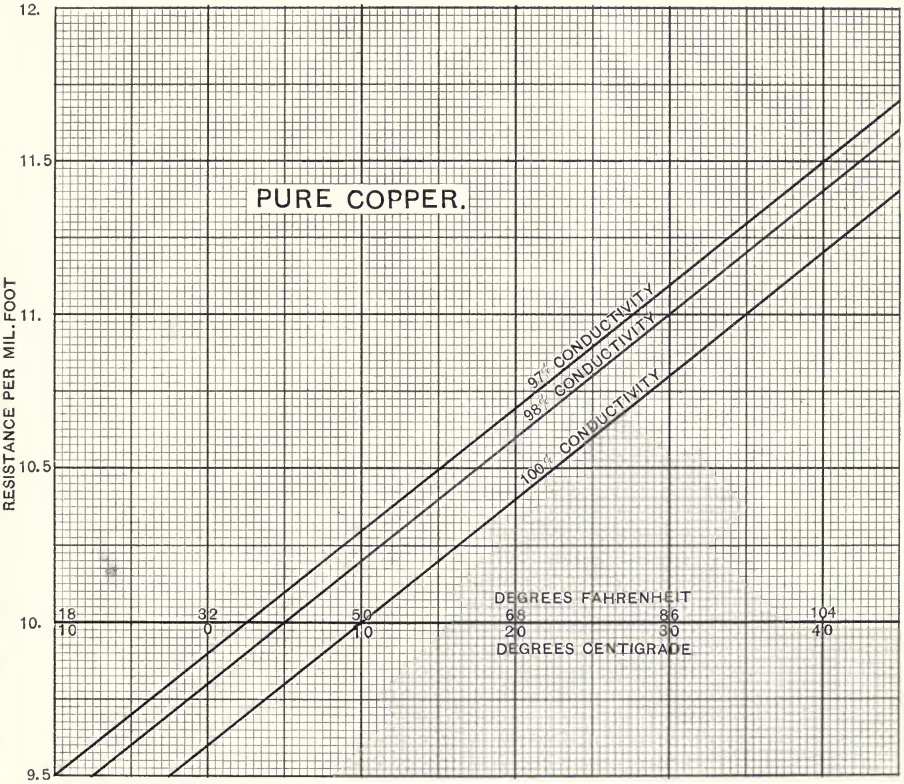
*Taken by permission from Foster's Electrical Engineer's Pocket Book published by D. Van Nostrand Company, New York.

General
Data

Resistance per Mil-Foot of Pure Copper at Various Temperatures and Conductivities

Values of K in expression $C\sqrt{t\frac{d^3}{K}}$



The heat radiating surface of any conductor varies as the diameter of the conductor, while the current carrying capacity, depending on the number of circular mils, will vary as the square of the diameter. In consequence, the current density in large conductors will be less than in small conductors for an equal temperature rise. It has been found impracticable on this account to use insulated conductors larger than 2,000,000 c. m., except in special cases. (See page 172.)

General Data

Carrying Capacities of Insulated Wires and Cables

Published in National Electrical Code of 1909

B. & S. Gauge Number	Capacity Circular Mils.	Amperes	
		Rubber Insulation	Weatherproof Insulation
18	1,624	3	5
16	2,583	6	8
14	4,107	12	16
12	6,530	17	23
10	10,380	24	32
8	16,510	33	46
6	26,250	46	65
5	33,100	54	77
4	41,740	65	92
3	52,630	76	110
2	66,370	90	131
1	83,690	107	156
0	105,500	127	185
00	133,100	150	220
000	167,800	177	262
...	200,000	200	300
0000	211,600	210	312
....	300,000	270	400
. ..	400,000	330	500
....	500,000	390	590
....	600,000	450	680
....	700,000	500	760
....	800,000	550	840
....	900,000	600	920
....	1,000,000	650	1,000
....	1,100,000	690	1,080
....	1,200,000	730	1,150
....	1,300,000	770	1,220
....	1,400,000	810	1,290
....	1,500,000	850	1,360
....	1,600,000	890	1,430
....	1,700,000	930	1,490
....	1,800,000	970	1,550
....	1,900,000	1,010	1,610
....	2,000,000	1,050	1,670

Drop of potential is not taken into consideration in the above table. These amperages for rubber-covered wires are adopted because to exceed them may cause gradual deterioration of the insulation even though the chance of ignition from overheating may be small.

Wires smaller than No. 14 should not be used except as prescribed in Underwriters' rules.

For aluminum wire the carrying capacity of any given size should be taken as 84 per cent. of the value given in the above table.

Pounds per Mile-Ohm of Copper Wire at Various Temperatures and Conductivities

General Data

Per Cent. Conductivity Matthiessen's Standard	Pounds per Mile-Ohm				Per Cent. Conductivity Matthiessen's Standard	Pounds per Mile-Ohm			
	At 32° F. 0° C.	At 60° F. 15.6° C.	At 68° F 20° C.	At 104° F. 40° C.		At 32° F. 0° C.	At 60° F. 15.6° C.	At 68° F. 20° C.	At 104° F. 40° C.
96.0	841.9	893.4	908.7	980.8	99.0	816.4	866.3	881.1	951.0
.2	840.2	891.5	906.8	978.7	.2	814.8	864.6	879.4	949.1
.4	838.4	889.7	904.9	976.7	.4	813.1	862.8	877.6	947.2
.6	836.7	887.8	903.0	974.7	.6	811.5	861.1	875.8	945.3
.8	835.0	886.0	901.2	972.7	.8	809.9	859.4	874.1	943.4
97.0	833.2	884.2	899.3	970.6	100.0	808.2	857.6	872.3	941.5
.2	831.5	882.4	897.4	968.7	.2	806.6	855.9	870.6	939.6
.4	829.8	880.5	895.6	966.7	.4	805.0	854.2	868.8	937.8
.6	828.1	878.7	893.8	964.7	.6	803.4	852.5	867.1	935.9
.8	826.4	876.9	891.9	962.7	.8	801.8	850.8	865.4	934.1
98.0	824.7	875.1	890.1	960.7	101.0	800.2	849.2	863.7	932.2
.2	823.1	873.4	888.3	958.8	.2	798.7	847.5	862.0	930.4
.4	821.4	871.6	886.5	956.8	.4	797.1	845.8	860.3	928.5
.6	819.7	869.8	884.7	954.9	.6	795.5	844.1	858.6	926.7
.8	818.1	868.1	882.9	953.0	.8	794.0	842.5	856.9	924.9
					102.0	792.4	840.8	855.2	923.1

Alternating Current Heating Effects

If an alternating current be transmitted through a conductor, portions of the electrical energy supplied may be transformed into heat in four different ways, each resulting in an energy loss and in a corresponding reduction of the current carrying capacity of the conductor.

1. A definite amount of electrical energy will be required to overcome the ohmic resistance of the conductor, just as in the case with continuous currents. This is commonly known as the I^2R loss, where I is the effective current.

2. Under certain conditions there will be loss of energy due to the *skin effect* of alternating currents. A current induced in a conductor builds up from the surface, and an appreciable period of time is required for the current to penetrate to the interior portions of the conductor. If the frequency be high the central portion of large conductors may contribute nothing to the conducting powers of the conductor. This is equivalent to increasing the resistance of the conductor, or in effect the conductor will have a spurious resistance which will be greater than its real resistance.

The effect is much greater in iron than in copper, owing to the high magnetic permeability of iron. It also increases directly with the frequency of alternations. With the two standard frequencies now being used, 25 and 60, the skin effect in copper does not become appreciable until a diameter of conductor of about three-quarters of an inch has been reached. In distribution systems which conduct heavy currents of high frequency, the conductor wires may be built up into cables about a hemp core, thus offering a greater amount of surface by placing the copper where it will do the greatest service without increasing its weight.

General Data

Approximate values of the effective resistance of straight copper conductors at 68 degrees F. can be obtained by multiplying the actual ohmic resistance by factors given in the following table:

Factors to Obtain Effective Resistance from Ohmic Resistance

Diameter Bare Copper Conductor Inches	Approximate Area in Circular Mils	Frequency			Diameter Bare Copper Conductor Inches	Approximate Area in Circular Mils	Frequency		
		25	60	130			25	60	130
2.00	4,000 000	1.265	1.826	2.560	1.000	1,000,000	1.020	1.111	1.397
1.75	3,062,500	1.170	1.622	2.272	.75	563,500	1.007	1.040	1.156
1.50	2,500,000	1.098	1.420	1.983	.50	250,000	1.002	1.008	1.039
1.25	1,562,500	1.053	1.239	1.694	.46	211,600	1.001	1.006	1.027
1.125	1,265,625	1.035	1.168	1.545					

3. *Foucoult* or eddy currents may be induced in the conductor itself, or in the lead sheathing or in the steel armor wires by the rapidly changing alternating magnetic flux. Foucoult currents are produced at the expense of energy supplied the conductor, and they are dissipated in the form of heat. This loss would be much greater in single-conductor cables carrying alternating current than in two-conductor or three-conductor cables, in which the outer resultant magnetic field should be very small. Placing a single-conductor alternating current cable in an iron conduit would very greatly increase the energy loss, and for that reason it is seldom done. This loss will be greater in solid conductors than in stranded conductors of equal section, and it will increase with thickness of lead sheath and with the diameter of the armor wires.

4. *Dielectric hysteresis* losses in the insulating material. This loss is somewhat similar in kind to the magnetic hysteresis loss in iron. A dielectric is a poorly conducting material used for insulating conductors, through which an electromotive force establishes a molecular strain or an electro-static field of flux. The total dielectric loss is due to the sum of a direct $I^2 R$ leakage of current through the dielectric and to the dielectric hysteresis loss, which is thought to be a function of the insulation resistance, varying inversely. The hysteresis loss in the dielectric of a cable is constant and independent of load. It increases with voltage, with the length of cable and with frequency. It may be lessened by increasing the thickness of the dielectric, by using a dielectric of low specific inductive capacity and by working at low voltage and low frequency. The loss is thought to be negligible in direct current systems and in low voltage alternating current distribution systems.

While the amount of heat developed under ordinary service conditions by any one of the last three mentioned causes would probably be small, yet the aggregate amount tends to increase the temperature of the conductor, which increases its resistance, reduces its carrying capacity and shortens the life of the insulation.

Measurements of Conductors

General Data

The diameter of a conductor is usually expressed in *mils*. A mil is a thousandth part of an inch. The direct measurement of diameters in mils is made by wire gauges, of which there are several different types on the market. One type in common use is shown in the cut below.

Micrometer Screw

The *circular mil* is very generally taken as the unit of area in considering the cross-section or capacity of electrical conductors. This is the area of a circle whose diameter is one mil, or one-thousandth of an inch. It equals .7854 of a square mil. This unit area possesses several advantages in making wiring calculations and in determining the relations between different wires having known diameters. The cross-section of any solid round wire in circular mils is found by squaring the diameter of the wire in mils, and conversely, the diameter of a wire in mils is obtained by extracting the square root of the section expressed in circular mils. The constant π, which expresses the ratio between the circumference and diameter of any circle, does not enter into these calculations, thus greatly simplifying them.

Circular mils = square inches $\div$ .0000007854 = (diameter in mils)^2
Square inches = circular mils $\times$ .0000007854
One circular mil = .0005067087 square millimeters
One square millimeter = 1,973 circular mils

The *weight* in pounds per 1,000 feet of any conductor may be found by multiplying its area in circular mils by the "pounds per 1,000 feet per circular mil," tabulated on page 14.

Wire Gauges

The sizes of wires are ordinarily expressed in certain gauge numbers arbitrarily chosen. There are unfortunately several independent gauge systems, and it is necessary in each case to specify the particular wire gauge used. Though the gauge numbers have the advantage of enabling manufacturers to carry wires in stock from which purchasers may choose with a reasonable assurance of quick delivery, there is nevertheless a tendency to do away with all gauge numbering methods and to distinguish different electrical wires by their diameters expressed in mils.

The Brown & Sharpe gauge is used in America as the standard for copper wire used for electrical purposes. In this gauge both the sizes and the areas vary in geometrical progression. The diameters of wires are obtained from the geometric series, in which the first number, No. 4/0, = 0.46 inch in diameter, and No. 36 = .005 inch, the nearest fourth significant figure being retained in the areas and diameters

General Data

so obtained. It will be seen upon examining a wiring table that an increase of three in the wire number corresponds to doubling the resistance and halving the cross-section and weight. Also, that an increase of ten in the wire number increases the resistance ten times and diminishes the cross-section and weight to one-tenth their original values.

The American Steel and Wire gauge is used almost universally in this country for steel and iron wires.

The Birmingham gauge is used largely in England as their standard, and in this country for steel wires, and for other wires not used especially for electrical purposes.

The following table gives the numbers and diameters in decimal parts of an inch for the various wire gauges used in this country and England:

Comparative Sizes Wire Gauges in Decimals of an Inch

No. of Wire Gauge	American Steel & Wire Gauge	Brown & Sharpe Gauge	Birmingham, or Stubs'	British Imperial Standard*	Old English or London	French	No. of Wire Gauge	American Steel & Wire Gauge	Brown & Sharpe Gauge	Birmingham, or Stubs'	British Imperial Standard*	Old English or London	French
0000000	.4900	......	....	.500	.....	....	18	.0475	.04030	.049	.048	.0490	.238
000000	.4615	.58000	....	.464	.....	....	19	.0410	.03589	.042	.040	.0400	.250
00000	.4305	.51650	.500	.432	.....	....	20	.0348	.03196	.035	.036	.0350	.263
0000	.3938	.46000	.454	.400	.4540	....	21	.0317	.02846	.032	.032	.0315	.279
000	.3625	.40964	.425	.372	.4250	....	22	.0286	.02535	.028	.028	.0295	.290
00	.3310	.36480	.380	.348	.3800	....	23	.0258	.02257	.025	.024	.0270	.303
0	.3065	.32486	.340	.324	.3400	....	24	.0230	.02010	.022	.022	.0250	.316
1	.2830	.28930	.300	.300	.3000	.033	25	.0204	.01790	.020	.020	.0230	.331
2	.2625	.25763	.284	.276	.2840	.040	26	.0181	.01594	.018	.018	.0205	.342
3	.2437	.22942	.259	.252	.2590	.050	27	.0173	.01420	.016	.0164	.01875	.356
4	.2253	.20431	.238	.232	.2380	.063	28	.0162	.01264	.014	.0148	.01650	.371
5	.2070	.18194	.220	.212	.2200	.068	29	.0150	.01126	.013	.0136	.01550	.383
6	.1920	.16202	.203	.192	.2030	.083	30	.0140	.01003	.012	.0124	.01375	.394
7	.1770	.14428	.180	.176	.1800	.097	31	.0132	.00893	.010	.0116	.01225	.408
8	.1620	.12849	.165	.160	.1650	.110	32	.0128	.00795	.009	.0108	.01125	.419
9	.1483	.11443	.148	.144	.1480	.120	33	.0118	.00708	.008	.0100	.01025	.431
10	.1350	.10189	.134	.128	.1340	.135	34	.0104	.00630	.007	.0092	.00950	.448
11	.1205	.09074	.120	.116	.1200	.149	35	.0095	.00561	.005	.0084	.00900	.458
12	.1055	.08081	.109	.104	.1090	.162	36	.0090	.00500	.004	.0076	.00750	.472
13	.0915	.07196	.095	.092	.0950	.172	37	.0085	.00445	....	.0068	.00650	.485
14	.0800	.06408	.083	.080	.0830	.185	38	.0080	.00396	....	.0060	.00575	.499
15	.0720	.05706	.072	.072	.0720	.197	39	.0075	.00353	....	.0052	.00500	.509
16	.0625	.05082	.065	.064	.0650	.212	40	.0070	.00314	....	.0048	.00450	.524
17	.0540	.04525	.058	.056	.0580	.225							

*Also called New British or English Legal Standard.

Wiring Formulæ and Tables

The current carrying capacity of a conductor is not only limited by its allowable temperature rise, as already explained, but also by the allowable drop of potential. The potential difference required to transmit a given electric current through a conductor will vary directly as the resistance of the conductor and inversely as its cross-sectional area. The diameter of conductors used for long distance transmission purposes is usually determined by the drop of potential allowable, rather than from other electrical considerations.

For most practical purposes the following formulæ can be used to determine the size of copper conductors, current per wire, and weight of copper per circuit for any system of electrical distribution.

$$\text{Area of conductor in circular mils} = \frac{D \times W}{P \times E^2} K = \text{C. M.}$$

$$\text{Current in main conductor} = \frac{W}{E} T. \quad P = \frac{D \times W}{\text{C. M.} \times E^2} K$$

General Data

$$\text{Weight of copper} = \frac{D^2 \times W \times K \times A}{P \times E^2 \times 1{,}000{,}000}, \text{ pounds.}$$

In these equations the symbols used denote the following quantities:

W = total watts delivered.
D = distance of transmission, one way in feet.
E = voltage between main conductors at the receiving or consumers' end of circuit.
P = loss in line in per cent. of power delivered, i. e., of W, this being a whole number. K, T and A are constants given in the following table:

Wiring Formulæ Constants

System	Values of A	Values of K					Values of T				
		Per Cent. Power Factor					Per Cent. Power Factor				
		100	95	90	85	80	100	95	90	85	80
1-phase, and D. C.	6.04	2160	2400	2660	3000	3380	1.00	1.05	1.11	1.17	1.25
2-phase-4 wire	12.08	1080	1200	1330	1500	1690	.50	.53	.55	.59	.66
3-phase-3 wire	9.06	1080	1200	1330	1500	1690	.58	.61	.64	.68	.72

These constants depend upon the system of distribution as well as the conditions of the circuit.

For continuous current K=2160, T=1 and A= 6.04.

For any particular power factor the value of K is obtained by dividing 2160, the value for continuous current, by the square of the power factor for single-phase, and by twice the square of the power factor for three-wire three-phase or four-wire two-phase. In continuous current Edison three-wire systems, the neutral should be made of one-third the section obtained by the formula for either of the outside mains. In both continuous and alternating current systems, the neutral conductor, for secondary mains (i. e., service connections) and house wiring, should be taken as large as the other conductor. The three wires of a three-phase circuit and the four wires of a two-phase circuit should all be of the same size, and each conductor should be of the cross-section, as obtained by the proper application of the first formula.

The following assumed values of power factors for circuits may be used in any calculation when their exact values are not known.

Incandescent lighting and synchronous motors, 95 per cent.

Lighting and induction motors, 85 per cent.

Induction motors alone, 80 per cent.

For *continuous currents* and for short branch circuits in wiring buildings, for lamp and motor outlets, the following formula for determining area of conductor is found more convenient to use.

$$\text{Circular mils} = \frac{10.8 \times \text{Amperes} \times \text{Length of circuit in feet.}}{\text{Volts permissible drop in wire.}}$$

For example: What size of wire would be required for an 800-foot circuit carrying current to a 500-volt, 20-kilowatt, direct current motor, allowing 2 per cent. drop in the circuit.

20 kilowatts=20,000 watts.
20,000÷500=40, amperes in line.
1 per cent. loss in each wire or branch of circuit=500 × .01=5 volts.
Length of each wire=800 feet.

$$\text{Circular mils} = \frac{10.8 \times 40 \times 800}{5} = 69{,}120 \text{ or No. 2 B. \& S. wire say}$$

for each branch of the circuit.

General Data

Bare Copper Wire Table

The data from which these tables have been computed are as follows: Matthiessen's standard resistivity, Matthiessen's temperature coefficients, specific gravity of copper = 8.89. Resistance in terms of the international ohm.

Brown & Sharpe Gauge	Diameter of Wire			Cross-sectional Area		
	In Inches	Allowable Variation in Per Cent. Either Way	In Millimeters	Circular Mils (d^2) $d = .001$ Inch	Square Inch ($d^2 \times .7854$)	Square Millimeter
0000	.4600	.45	11.68	211600.	.166190	107.219
000	.4096	.50	10.40	167772.	.131770	85.011
00	.3648	.50	9.266	133079.	.104520	67.432
0	.3250	.50	8.255	105625.	.082958	53.521
1	.2893	.50	7.348	83694.	.065733	42.408
2	.2576	.50	6.543	66358.	.052117	33.624
3	.2294	.75	5.827	52624.	.041331	26.665
4	.2043	.75	5.189	41738.	.032781	21.149
5	.1819	.75	4.620	33088.	.025987	16.766
6	.1620	.75	4.115	26244.	.020612	13.298
7	.1443	.75	3.665	20822.	.016354	10.550
8	.1285	1.00	3.264	16512.	.012969	8.3666
9	.1144	1.00	2.906	13087.	.010279	6.6313
10	.1019	1.00	2.588	10384.	.0081553	5.2614
11	.0907	1.00	2.304	8226.5	.0064611	4.1684
12	.0808	1.25	2.052	6528.6	.0051276	3.3081
13	.0720	1.25	1.829	5184.0	.0040715	2.6267
14	.0641	1.25	1.628	4108.8	.0032271	2.0819
15	.0571	1.25	1.450	3260.4	.0025607	1.6520
16	.0508	1.50	1.290	2580.6	.0020268	1.3076
17	.0453	1.50	1.151	2052.1	.0016117	1.0398
18	.0403	1.50	1.024	1624.1	.0012756	.82294
19	.0359	1.75	.9119	1288.8	.0010122	.65304
20	.0320	1.75	.8128	1024.0	.00080425	.51887
21	.0285	1.75	.7239	812.25	.00063794	.41157
22	.0253	1.75	.6426	640.09	.00050273	.32434
23	.0226	2.00	.5740	510.76	.00040115	.25880
24	.0201	2.00	.5105	404.01	.00031731	.20471
25	.0179	2.00	.4547	320.41	.00025165	.16235
26	.0159	2.00	.4039	252.81	.00019856	.12810
27	.0142	2.00	.3607	201.64	.00015837	.10217
28	.0126	2.00	.3200	158.76	.00012469	.08044
29	.0113	2.00	.2870	127.69	.00010029	.06470
30	.0100	2.50	.2540	100.00	.000078540	.05067
31	.00893	3.00	.2268	79.74	.000062631	.04040
32	.00795	3.00	.2019	63.20	.000049639	.03202
33	.00708	3.00	.1798	50.13	.000039369	.02540
34	.00630	3.50	.1600	39.69	.000031173	.02011
35	.00561	4.00	.1425	31.47	.000024718	.01594
36	.0050	4.50	.1270	25.00	.000019635	.01266
37	.00445	5.00	.1130	19.80	.000015553	.01003
38	.00396	6.00	.1006	15.68	.000012316	.00794
39	.00353	7.00	.08966	12.46	.0000097868	.00631
40	.00314	8.00	.07976	9.86	.0000077437	.00499

Bare Copper Wire Table

Giving dimensions, weights, lengths and resistances of bare round solid wires, Matthiessen's Standard of Conductivity. While these values are theoretically correct, slight variation should be expected in practice.

Pounds per		Ohms per			Feet per		Brown & Sharpe Gauge
1000 Feet	Ohm at 20 C. 68 F.	Pound at 20 C. 68 F.	1000 Feet at 20 C. 68 F.	1000 Feet at 50 C. 122 F.	Pound	Ohm at 20 C. 68 F.	
640.5	13,090	.0000764	.04893	.05467	1.561	20,440	0000
508.0	8,232	.0001215	.06170	.06893	1.969	16,210	000
402.8	5,177	.0001931	.07780	.08692	2.482	12,850	00
319.5	3,256	.0003071	.09811	.1096	3.130	10,190	0
253.3	2,048	.0004883	.1237	.1382	3.947	8,083	1
200.9	1,288	.0007765	.1560	.1743	4.977	6,410	2
159.3	810.0	.001235	.1967	.2198	6.276	5,084	3
126.4	509.4	.001963	.2480	.2771	7.914	4,031	4
100.2	320.4	.003122	.3128	.3495	9.980	3,197	5
079.46	201.5	.004963	.3944	.4406	12.58	2,535	6
063.02	126.7	.007892	.4973	.5556	15.87	2,011	7
49.98	79.69	.01255	.6271	.7007	20.01	1,595	8
39.63	50.12	.01995	.7908	.8835	25.23	1,265	9
31.43	31.52	.03173	.9972	1.114	31.82	1,003	10
24.93	19.82	.05045	1.257	1.405	40.12	795.3	11
19.77	12.47	.08022	1.586	1.771	50.59	630.7	12
15.68	7.840	.1276	1.999	2.234	63.79	500.1	13
12.43	4.931	.2028	2.521	2 817	80.44	396.6	14
9.858	3.101	.3225	3.179	3.552	101.4	314.5	15
7.818	1.950	.5128	4.009	4.479	127.9	249.4	16
6.200	1.226	.8153	5.055	5.648	161.3	197.8	17
4.917	.7713	1.296	6.374	7.122	203.4	156.9	18
3.899	.4851	2.061	8.038	8.980	256.5	124.4	19
3.092	.3051	3.278	10.14	11.32	323.4	98.66	20
2.452	.1919	5.212	12.78	14.28	407.8	78.24	21
1.945	.1207	8.287	16.12	18.01	514.2	62.05	22
1.542	.07589	13.18	20.32	22.71	648.4	49.21	23
1.223	.04773	20.95	25.63	28.63	817.6	39.02	24
.9699	.03002	33.32	32.31	36.10	1,031	30.95	25
.7692	.01888	52.97	40.75	45.52	1,300	24.54	26
.6100	.01187	84.23	51.38	57.40	1,639	19.46	27
.4837	.007466	133.9	64.79	72.39	2,067	15.43	28
.3836	.004696	213.0	81.70	91.28	2,607	12.24	29
.3042	.002953	338.6	103.0	115.1	3.287	9.707	30
.2413	.001857	538.4	129.9	145.1	4,145	7.698	31
.1913	.001168	856.2	161.8	183.0	5,227	6.105	32
.1517	.0007346	1,361	206.6	230.8	6,591	4.841	33
.1203	.0004620	2,165	260.5	291.0	8,311	3.839	34
.09543	.0002905	3,441	328.4	366.9	10,480	3.045	35
.07568	.0001827	5,473	414.2	462.7	13,210	2.414	36
.06001	.0001149	8.702	522.2	583.5	16,660	1.915	37
.04759	.00007210	13,870	658.5	735.7	21,010	1.519	38
.03774	.00004545	22,000	830.4	927.7	26,500	1.204	39
.02993	.00002858	34,980	1047.0	1170.0	33,410	0.955	40

General Data

Weight per 1,000 Feet of Bare Copper Wire in Pounds

Number	American Standard (B. & S.)	American Steel & Wire Co.	Birmingham or Stubs'	British Imperial Standard
000000	1017.	643.9	. . .	650.4
00000	806.6	560.3	755.9	564.3
0000	639.8	468.9	623.2	483.8
000	507.3	397.3	546.1	418.4
00	402.4	331.3	436.6	366.2
0	319.4	284.0	349.5	317.4
1	253.0	242.1	272.1	272.1
2	200.6	208.3	243.9	230.3
3	159.1	179.6	202.8	192.0
4	126.2	153.5	171.3	162.7
5	100.0	129.6	146.3	135.9
6	79.35	111.5	124.6	111.5
7	62.96	94.72	97.96	93.66
8	49.92	79.35	82.31	77.40
9	39.57	66.49	66.23	62.69
10	31.39	56.10	54.29	49.54
11	24.87	43.90	43.54	40.68
12	19.74	33.65	35.92	32.70
13	15.67	25.31	27.29	25.59
14	12.42	19.35	20.83	19.35
15	9.858	15.67	15.67	15.67
16	7.802	11.81	12.77	12.38
17	6.204	8.816	10.17	9.482
18	4.910	6.822	7.259	6.966
19	3.897	5.082	5.333	4.838
20	3.096	3.662	3 704	3.918
21	2.456	3.038	3.096	3.096
22	1.935	2.473	2.370	2.370
23	1.544	2.013	1.890	1.742
24	1.222	1.599	1.463	1.463
25	0.9688	1.258	1.209	1.209
26	0.7644	0.9905	0.9796	0.9796
27	0.6097	0.9049	0.7740	0.8132
28	0.4800	0.7935	0.5926	0.6623
29	0.3861	0.6803	0.5110	0.5592
30	0.3023	0.5926	0.4354	0.4649
31	0.2411	0.5268	0.3023	0.4068
32	0.1911	0.4954	0.2449	6.3527
33	0.1516	0.4210	0.1935	0.3023
34	0.1200	0.3270	0.1481	0.2559
35	0.09515	0.2729	0.07559	0.2133
36	0.07559	0.2449	0.04838	0.1746
37	0.05987	0.2184	. . . .	0.1398
38	0.04741	0.1935	. . . .	0.1088
39	0.03768	0.1701	. . . .	0.08175
40	0.02981	0.1481	. . . .	0.06966

1000 feet of pure copper wire of one circular mil capacity weighs 0.003027057 pound.

Tensile Strength of Pure Copper Wire in Pounds

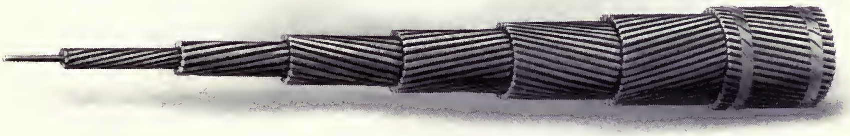
Size B. & S.	Hard Drawn		Annealed		Size B. & S.	Hard Drawn		Annealed	
	Actual	Average per Square Inch	Actual	Average per Square Inch		Actual	Average per Square Inch	Actual	Average per Square Inch
0000	8260.	49,700	5320.	32,000	7	1050.	64,200	556.	34,000
000	6550.	49,700	4220.	32,000	8	843.	65.000	441.	34.000
00	5440.	52,000	3340.	32,000	9	678.	66,000	350.	34,000
0	4530.	54,600	2650.	32,000	10	546.	67,000	277.	34,000
1	3680.	56.000	2100.	32,000	12	343.	67,000	174.	34,000
2	2970.	57,000	1670.	32,000	14	219.	68,000	110.	34,000
3	2380.	57,600	1323.	32.000	16	138.	68,000	68.9	34,000
4	1900.	58,000	1050.	32,000	18	86.7	68,000	43.4	34,000
5	1580.	60,800	884.	34,000	19	68.8	68,000	34.4	34,000
6	1300.	63,000	700.	34,000	20	54.7	68,000	27.3	34,000

General Data

Strand

If a solid copper wire be made larger in diameter than 0.46 inch it becomes hard to splice and difficult to handle, owing to its size and stiffness. Conductors larger than this are nearly always built up of small wires twisted into a strand or cable. The flexibility of a cable will increase as the size of the constituent wires decreases or as the number of wires increases, and it will depend somewhat upon the method of laying up the cable.

While it is possible to build up a cable from any number of wires, there are certain combinations only that can be used to obtain a smooth and symmetrical cable. These combinations are governed by well established geometrical rules which should be observed whenever possible.



Seven-layer Strand

A bare *cable* may be defined as consisting of any group of wires twisted together helically, or it may be composed of any number of such groups. The term *wire* indicates the individual solid wires in a cable.

A *strand* is a group of single wires in one or more layers, twisted together helically and symmetrically with a uniform pitch around a single central wire or neutral axis. This construction is sometimes called *concentric strand.*

The term *bunched strand* is sometimes applied to a collection of straight or twisted wires which are grouped together with little regard to their geometrical arrangements.

The above cut represents the manner in which a concentric strand with 7 layers is built up. The first layer consists of six wires twisted spirally around the central wire or core. The second layer has 12 wires or 6 + 6, the third 18 wires or 12 + 6, and so on, each succeeding layer having 6 more wires than the one underneath. The total number of wires in this type of strand would be,

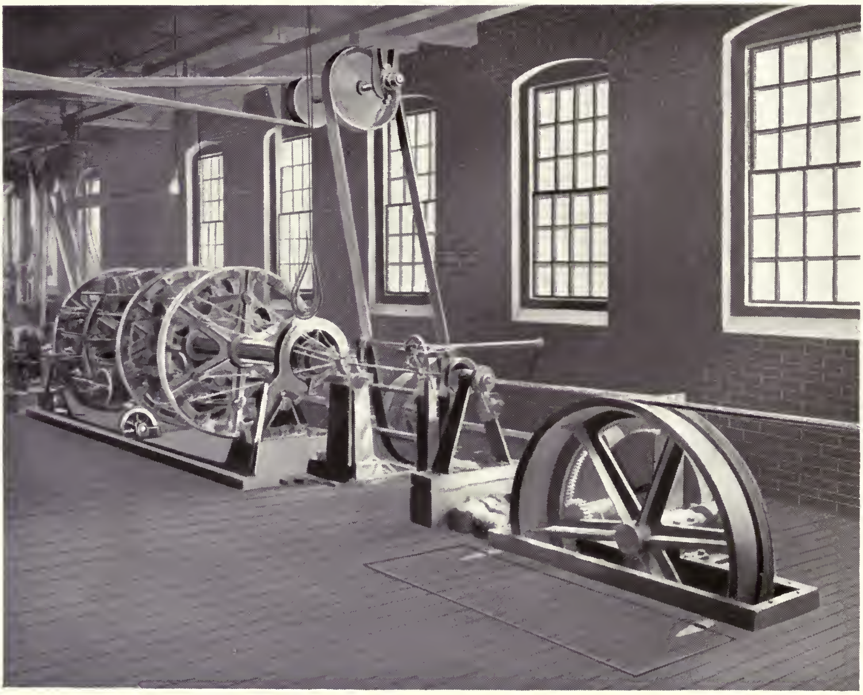
For 1 layer, 1 + 6 = 7
2 layers, 7 + 12 = 19
3 layers, 19 + 18 = 37
4 layers, 37 + 24 = 61
7 layers, 127 + 42 = 169

This can be expressed by the following formula, where n is the number of layers over the core:

$$\text{Total number of wires} = 3n(1 + n) + 1.$$

General Data

In this type of strand, all wires are of the same size and each successive layer of wires after the second is twisted in a reverse direction from the preceding one, making the external diameter symmetrical and cylindrical. It is the most compact form, it has the smallest diameter for a given capacity and presents the smoothest and most uniform external surface possible to obtain. These are very necessary qualifications for the production of a high grade insulated cable. The insulation, whether it be rubber, paper, cambric or other material, will have a more uniform thickness on a concentric strand than on any other, due to the evenness of its external diameter.



Stranding Machine

As the successive layers are wound in opposite directions, the wires will not fit into the grooves between the wires underneath. The diameter of such a strand will therefore equal the sum of the diameters of the individual wires crossing each other in any diameter. It will equal $d(2n + 1)$, where d is the diameter of each wire and n the number of layers.

The axial length of one complete turn of a wire in a strand is called the *pitch*, or the *lay* of the strand. This is often expressed in terms of the diameter of the strand. There is no one fixed standard pitch used by all cable makers. An extended experience in cable making has shown us that the particular system of laying wires in a strand outlined in the following table gives best results. This is based on placing the wires in the strand at a uniform angle with the core. The "per cent. take-up of whole strand" represents also the per cent. increase in weight of a strand over a solid wire of equal cross-section.

Standard Pitch of Concentric Copper Strand

Number of Wires in Strand	Number in Outside Layer	Per Cent. Take-up Each Layer	Per Cent Take-up of Whole Strand	Approximate Diameters Pitch	Angle of Wire	Cosine of Angle	Approximate Weight per 100,000 Circular Mils per 1,000 Feet Strand
1	. .	. .	. .	. .	. . .	. . .	302.7058
7	6	0.97	0.83	15	8°-0′	.9902	305.218
19	12	2.63	1.97	11	13°-0′	.9744	308.669
37	18	2.63	2.29	12	13°-0′	.9744	309.638
61	24	2.63	2.42	12	13°-0′	.9744	310.031
91	30	2.63	2.49	12½	13°-0′	.9744	310.243
127	36	2.63	2.53	12½	13°-0′	.9744	310.364
169	42	2.63	2.55	12½	13°-0′	.9744	310.425
217	48	2.63	2.57	12½	13°-0′	.9744	310.485
7 x 7 = 49	6 Wires	0.97	. .	15	8°-0′	.9903	309.244
Rope Strand	6 Strands	1.54	2.16	12	10°-0′	.9848	. . . .

If a longer twist were used than that given in the above table, the wires in the strand would not bind together properly, and if a shorter twist be employed, the per cent. of take-up of the wires and the weight would be increased.

The best copper strands are made on machinery which permits the wires to be laid into the strand without torsion. Where torsion is present, it has a bad effect on the strand and on the physical characteristics of the wire.

The sectional area of a cable in circular mils is obtained by multiplying the area of each wire in circular mils measured at right angles to its axis, by the number of wires. Copper strands larger in sectional area than 4/0 B. & S. gauge are usually classified according to their total area in circular mils; smaller copper cables are nearly always classified in the B. & S. gauge. The area in circular mils (d^2) of any one wire equals the circular mils of the cable divided by the number of wires in the cable. The diameter of any wire in mils will equal, as explained elsewhere, the square root ($\sqrt{d^2}$) of the area of the wire expressed in circular mils. The individual wires of a cable can seldom be drawn to any of the standard gauge numbers, because the diameter of the wire is fixed by the required size of the cable, and the number of wires composing it.

General Data

Diameters of Strands and Component Wires

Size in Circular Mils	7-Wire Strand		19-Wire Strand		37-Wire Strand		61-Wire Strand	
	Diameter of Each Wire	Diameter of Strand	Diameter of Each Wire	Diameter of Strand	Diameter of Each Wire	Diameter of Strand	Diameter of Each Wire	Diameter of Strand
100,000	.1196	.3588	.0726	.3628	.0520	.3640	.0405	.3645
125,000	.1337	.4011	.0811	.4055	.0581	.4167	.0453	.4077
150,000	.1463	.4389	.0889	.4445	.0636	.4442	.0496	.4464
175,000	.1581	.4743	.0960	.4800	.0688	.4716	.0535	.4815
200,000	.1690	.5070	.1026	.5130	.0735	.5145	.0573	.5157
225,000	.1793	.5379	.1088	.5440	.0780	.5460	.0607	.5463
250,000	.1890	.5670	.1147	.5735	.0822	.5754	.0640	.5760
275,000	.1982	.5946	.1203	.6015	.0862	.6034	.0671	.6039
300,000	.2070	.6210	.1257	.6285	.0901	.6307	.0701	.6309
325,000	.2155	.6465	.1308	.6540	.0937	.6559	.0730	.6570
350.000	.2236	.6708	.1357	.6785	.0973	.6811	.0757	.6813
375,000	.2312	.6936	.1405	.7025	.1007	.7049	.0784	.7056
400,000	.2391	.7173	.1451	.7255	.1040	.7280	.0810	.7290
425,000	.2464	.7392	.1495	.7475	.1072	.7504	.0835	.7515
450,000	.2535	.7605	.1539	.7695	.1103	.7721	.0859	.7731
475,000	.2604	.7812	.1581	.7905	.1133	.7931	.0882	.7938
500,000	.2672	.8016	.1622	.8110	.1162	.8134	.0905	.8145
525,000	.2738	.8217	.1662	.8310	.1191	.8337	.0928	.8352
550,000	.2803	.8409	.1701	.8505	.1219	.8533	.0950	.8550
575,000	.2866	.8608	.1740	.8700	.1247	.8729	.0971	.8739
600,000	.2928	.8784	.1778	.8890	.1273	.8911	.0992	.8928
625,000	.2988	.8964	.1814	.9070	.1299	.9093	.1012	.9108
650 000	.3047	.9141	.1850	.9250	.1325	.9275	.1032	.9288
675,000	.3106	.9316	.1885	.9425	.1351	.9457	.1052	.9468
700,000	.3163	.9489	.1919	.9595	.1375	.9625	.1071	.9639
725.000	.3218	.9654	.1953	.9765	.1400	.9800	.1090	.9810
750,000	.3273	.9819	.1986	.9930	.1424	.9968	.1109	.9981
775,000	.3328	.9984	.2019	1.0095	.1447	1.0129	.1127	1.0103
800,000	.3380	1.0140	.2052	1.0260	.1470	1.0290	.1145	1.0305
825,000	.3433	1.0299	.2084	1.0420	.1493	1.0451	.1163	1.0467
850,000	.3484	1.0452	.2115	1.0575	.1516	1.0612	.1181	1.0629
875,000	.3535	1.0605	.2146	1.0730	.1538	1.0766	.1198	1.0782
900,000	.3586	1.0758	.2176	1.0880	.1559	1.0913	.1215	1.0935
925,000	.3635	1.0905	.2206	1.1030	.1582	1.1074	.1231	1.1079
950.000	.3684	1.1052	.2236	1.1180	.1602	1.1214	.1248	1.1232
975,000	.3732	1.1196	.2265	1.1325	.1623	1.1361	.1264	1.1376
1,000,000	.3780	1.1340	.2294	1.1470	.1644	1.1508	.1280	1.1520
1,100,000	.3964	1.1892	.2406	1.2030	.1724	1.2068	.1343	1.2087
1,200.000	.4140	1.2420	.2513	1.2565	.1801	1.2607	.1402	1.2618
1,250,000	.4223	1.2678	.2565	1.2825	.1838	1.2866	.1431	1.2879
1,300.000	.4309	1.2927	.2616	1.3080	.1874	1.3018	.1459	1.3131
1,400.000	.4472	1.3416	.2714	1.3570	.1945	1.3615	.1515	1.3635
1,500,000	.4629	1.3887	.2810	1.4050	.2013	1.4091	.1568	1.4112
1,600,000	.4780	1.4340	.2902	1.4510	.2079	1.4553	.1619	1.4571
1,700,000	.4931	1.4793	.2991	1.4955	.2143	1.5001	.1669	1.5021
1,750.000	.5000	1.5000	.3034	1.5170	.2175	1.5225	.1694	1.5246
1,800 000	.5071	1.5213	.3078	1.5390	.2205	1.5435	.1718	1.5462
1,900,000	.5210	1.5630	.3162	1.5810	.2266	1.5862	.1765	1.5885
2,000,000	.5345	1.6035	.3243	1.6215	.2325	1.6275	.1810	1.6900

Size of Strand B. & S.	7-Wire Strand		19-Wire Strand		37-Wire Strand	
	Diameter of Each Wire	Diameter of Strand	Diameter of Each Wire	Diameter of Strand	Diameter of Each Wire	Diameter of Strand
10	.0385	.1155	.0233	.1165	.0168	.1176
9	.0435	.1305	.0262	.1310	.0187	.1309
8	.0485	.1455	.0293	.1465	.0211	.1477
7	.0545	.1635	.0331	.1655	.0237	.1659
6	.0612	.1836	.0372	.1860	.0266	.1862
5	.0687	.2061	.0417	.2085	.0299	.2093
4	.0772	.2316	.0468	.2340	.0335	.2345
3	.0867	.2601	.0526	.2630	.0377	.2639
2	.0973	.2919	.0592	.2960	.0423	.2961
1	.1093	.3279	.0663	.3315	.0475	.3325
0	.1228	.3684	.0746	.3730	.0534	.3738
00	.1378	.4134	.0836	.4180	.0599	.4193
000	.1548	.4644	.0940	.4700	.0673	.4711
0000	.1736	.5208	.1055	.5275	.0756	.5292

General Data

Diameters of Strands and Component Wires

91-Wire Strand		127-Wire Strand		169-Wire Strand		217-Wire Strand		Size in Circular Mils.
Diameter of Each Wire	Diameter of Strand	Diameter of Each Wire	Diameter of Strand	Diameter of Each Wire	Diameter of Strand	Diameter of Each Wire	Diameter of Strand	
.0331	.3641	.0281	.3653	.0243	.3645	.0215	.3655	100,000
.0371	.4081	.0314	.4082	.0272	.4080	.0240	.4080	125,000
.0406	.4466	.0343	.4459	.0298	.4470	.0263	.4471	150,000
.0438	.4818	.0371	.4823	.0322	.4830	.0284	.4828	175,000
.0469	.5159	.0397	.5161	.0344	.5160	.0304	.5168	200,000
.0497	.5467	.0421	.5473	.0365	.5475	.0322	.5474	225,000
.0524	.5764	.0444	.5746	.0384	.5760	.0340	.5780	250,000
.0549	.6039	.0465	.6045	.0403	.6045	.0356	.6052	275,000
.0573	.6303	.0486	.6318	.0421	.6315	.0372	.6324	300,000
.0597	.6567	.0506	.6579	.0438	.6570	.0387	.6579	325,000
.0620	.6820	.0526	.6838	.0455	.6825	.0401	.6817	350,000
.0642	.7062	.0543	.7059	.0471	.7065	.0415	.7055	375,000
.0663	.7293	.0561	.7293	.0487	.7305	.0429	.7293	400,000
.0683	.7513	.0579	.7527	.0501	.7515	.0442	.7514	425,000
.0703	.7733	.0595	.7735	.0516	.7740	.0455	.7735	450,000
.0722	.7942	.0612	.7956	.0530	.7950	.0468	.7956	475,000
.0741	.8151	.0627	.8151	.0544	.8160	.0480	.8160	500,000
.0759	.8349	.0643	.8359	.0557	.8355	.0492	.8364	525,000
.0777	.8547	.0658	.8554	.0570	.8550	.0503	.8551	550,000
.0795	.8745	.0673	.8749	.0583	.8745	.0514	.8738	575,000
.0812	.8932	.0687	.8931	.0596	.8940	.0526	.8942	600,000
.0829	.9119	.0702	.9126	.0608	.9120	.0537	.9129	625,000
.0845	.9295	.0716	.9308	.0620	.9300	.0547	.9299	650,000
.0861	.9471	.0729	.9487	.0632	.9480	.0558	.9486	675,000
.0883	.9713	.0742	.9646	.0644	.9660	.0568	.9656	700,000
.0892	.9812	.0756	.9828	.0655	.9825	.0578	.9826	725,000
.0908	.9988	.0768	.9984	.0666	.9990	.0588	.9996	750,000
.0923	1.0153	.0781	1.0153	.0677	1.0155	.0598	1.0166	775,000
.0937	1.0307	.0794	1.0322	.0688	1.0320	.0607	1.0319	800,000
.0952	1.0472	.0806	1.0478	.0698	1.0470	.0617	1.0489	825,000
.0966	1.0626	.0818	1.0634	.0709	1.0635	.0626	1.0642	850,000
.0981	1.0791	.0830	1.0790	.0719	1.0785	.0635	1.0795	875,000
.0994	1.0934	.0841	1.0933	.0730	1.0950	.0644	1.0948	900,000
.1008	1.1088	.0853	1.1089	.0740	1.1100	.0653	1.1101	925,000
.1021	1.1231	.0864	1.1232	.0750	1.1250	.0662	1.1254	950,000
.1035	1.1385	.0876	1.1388	.0760	1.1400	.0671	1.1407	975,000
.1048	1.1528	.0887	1.1531	.0769	1.1535	.0679	1.1543	1,000,000
.1099	1.2089	.0931	1.2103	.0807	1.2105	.0712	1.2104	1,100,000
.1148	1.2628	.0972	1.2636	.0843	1.2645	.0744	1.2648	1,200,000
.1172	1.2892	.0992	1.2896	.0860	1.2900	.0759	1.2903	1,250,000
.1195	1.3145	.1011	1.3143	.0877	1.3155	.0774	1.3158	1,300,000
.1240	1.3640	.1050	1.3650	.0910	1.3650	.0803	1.3651	1,400,000
.1284	1.4124	.1087	1.4132	.0942	1.4130	.0831	1.4127	1,500,000
.1326	1.4526	.1122	1.4586	.0973	1.4595	.0859	1.4603	1,600,000
.1366	1.5026	.1157	1.5041	.1003	1.5045	.0885	1.5045	1,700,000
.1386	1.5246	.1174	1.5262	.1018	1.5270	.0898	1.5266	1,750,000
.1406	1.5466	.1190	1.5470	.1032	1.5480	.0911	1.5487	1,800,000
.1445	1.5895	.1223	1.5899	.1060	1.5900	.0936	1.5912	1,900,000
.1482	1.6302	.1255	1.6315	.1088	1.6320	.0960	1.6320	2,000,000

61-Wire Strand		91-Wire Strand		127-Wire Strand		Size of Strand B. & S.
Diameter of Each Wire	Diameter of Strand	Diameter of Each Wire	Diameter of Strand	Diameter of Each Wire	Diameter of Strand	
.0129	.1161	.0106	.1166	.0090	.1170	10
.0146	.1314	.0120	.1320	.0101	.1313	9
.0164	.1476	.0135	.1485	.0114	.1482	8
.0184	.1656	.0151	.1661	.0128	.1664	7
.0207	.1863	.0169	.1859	.0143	.1859	6
.0233	.2097	.0190	.2090	.0161	.2093	5
.0261	.2349	.0214	.2354	.0179	.2327	4
.0294	.2646	.0240	.2640	.0203	.2639	3
.0329	.2943	.0269	.2959	.0228	.2964	2
.0370	.3330	.0303	.3333	.0252	.3276	1
.0416	.3744	.0340	.3740	.0288	.3744	0
.0467	.4203	.0382	.4202	.0323	.4199	00
.0525	.4725	.0429	.4719	.0363	.4719	000
.0589	.5301	.0482	.5302	.0408	.5304	0000

General Data

Resistance of Copper Strand

There is a division of opinion as to whether the electrical resistance of an annealed copper strand is equal to or greater than that of a solid annealed conductor of equal sectional area. The separate wires, on account of being laid up spirally, are longer than they would be if laid up parallel to the core, by an amount given in the table on page 29. If the electric current flows spirally through the separate wires and not through the strand as a unit, from wire to wire, then the effective length of the circuit has been increased, and also the resistance. On the other hand, the weight of the strand is greater than that of a solid wire by a proportionate amount, and this would reduce the resistance in strands where the current flowed from wire to wire. In any event the difference would rarely exceed one per cent. In case of hard drawn copper, however, there is no question as to the strand having a higher resistance than a solid wire of equal section.

Concentric Cables

Smooth symmetrical cables can be built up about a core of more than one wire, though this is seldom done in practice.

Wires in Concentric Cables

Number of Layers Over Core	Core of One Wire		Core of Two Wires		Core of Three Wires		Core of Four Wires	
	Wires per Layer	Total Number of Wires	Wires per Layer	Total Number of Wires	Wires per Layer	Total Number of Wires	Wires per Layer	Total Number of Wires
1	6	7	8	10	9	12	10	14
2	12	19	14	24	15	27	16	30
3	18	37	20	44	21	48	22	52
4	24	61	26	70	27	75	28	80
5	30	91	32	102	33	108	34	114
6	36	127	38	140	39	147	40	154
7	42	169	44	184	45	192	46	200

Rope Strands

A bare *rope strand* consists of a group of strands twisted together helically and symmetrically with a uniform pitch around a central strand. A rope is sometimes called a *compound strand* and sometimes cable laid strand. It differs from the concentric strand already considered, in that it is more flexible and that strands are substituted for individual wires.

The number and arrangement of strands in such a cable are similar to those of wires in a concentric strand. The total number of wires in a rope strand would equal the number of wires in a correspondingly constructed concentric strand, multiplied by the number of wires in the core. Or, expressed by formula, the total number of wires would equal

$$C \times [3n\,(1 + n) + 1]$$

Where C is the number of wires in the core or central strand, preferably 7, and n is the number of layers over the core.

Wires in Rope Strand

Number of Layers Over Core	Number of Strands in Cable	Total Number of Wires	
		7 Wires per Strand	19 Wires per Strand
1	7	49	133
2	19	133	361
3	37	259	703
4	61	427	1159
5	91	637	1729
6	127	889	2413

The diameter of a rope strand would equal

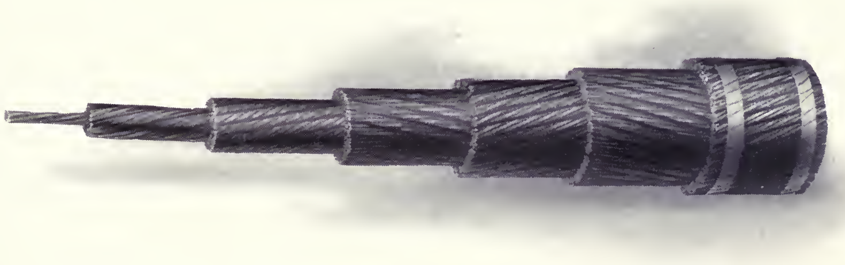
$$D\ (1 + 2n)$$

Where D is the diameter of each strand and n is the number of layers over the core. As explained on page 29, $D = d\ (1 + 2n)$ where d is the diameter of the single wire.

For example: The outside diameter of 4-layer 61 × 7 rope-strand in which the diameter of each strand D=0.3 inch would be

$$.3(1 + 2 \times 4) = 2.7 \text{ inches.}$$

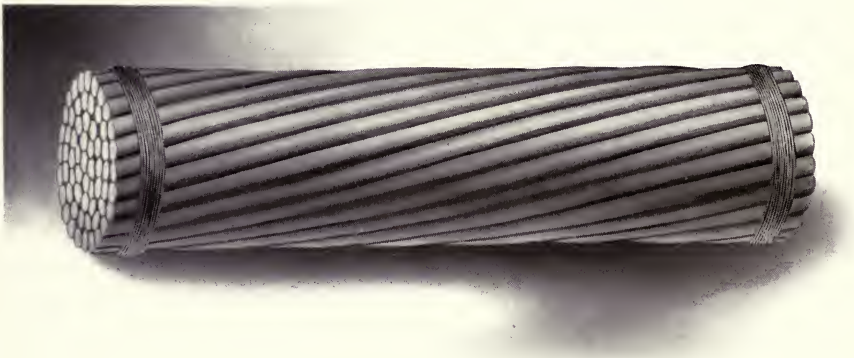
The diameters so obtained are usually about 5 per cent. larger than the finished diameter of the rope stranded cable owing to inherent characteristics of this type of construction.



Rope Strand

The manner of building up a rope-stranded cable is shown in the above cut. The number of wires in each strand which it is preferable to use is seven. Groups of such strands around a central core will form successively a 7 × 7, 19 × 7, 37 × 7, 61 × 7 and 127 × 7 rope strand. Such expressions as "19 × 7" mean 19 strands of 7 wires each, the number of strands always being given first. Wherever this method of designating compound strands is used it will be understood in this manner. The better construction for electrical conductors is to use, say, a 37-strand of 7 wires instead of a 7-strand of 37 wires, because the former is more compact and has a smoother external surface around which to place the insulation. This will be evident from a casual glance at a sectional view of such a cable. The 7 × 7 construction is not advisable on large conductors, as it is unwieldy and uneconomical. Its use is confined to the smaller sizes like 4 B. & S. gauge and smaller.

General
Data



Data Ralating to Bare Copper Strand

Approximate Values

B. & S. Gauge	Circular Mils	Number Wires in Strand	Diameter Each Wire Inches	Diameter of Strand Inches	Weight per 1000 Foot Strand Pounds	Area Strand Square Inches	Resistance per 1000 Feet at 68° F. or 20° C.
. .	2,000,000	91	.1482	1.6302	6204.8	1.56874	.00530
. .	1,750,000	91	.1387	1.5257	5429.3	1.36494	.00607
. .	1,500,000	91	.1284	1.4124	4653.6	1.17831	.00707
. .	1,250,000	91	.1172	1.2892	3878.0	.98170	.00852
. .	1,000,000	61	.1280	1.1520	3100.3	.78494	.01060
. .	950,000	61	.1248	1.1232	2945.3	.74618	.01115
. .	900,000	61	.1215	1.0935	2790.3	.70724	.01179
. .	850,000	61	.1181	1.0629	2635.3	.66852	.01247
. .	800,000	61	.1145	1.0305	2480.2	.62810	.01325
. .	750,000	61	.1109	.9981	2325.2	.58922	.01413
. .	700,000	61	.1071	.9639	2170.2	.54954	.01514
. .	650,000	61	.1032	.9288	2015.2	.51020	.01630
. .	600,000	61	.0992	.8928	1860.2	.47146	.01767
. .	550,000	37	.1219	.8533	1703.0	.43181	.01925
. .	500,000	37	.1162	.8134	1548.2	.39237	.02116
. .	450,000	37	.1103	.7721	1393.4	.35234	.02349
. .	400,000	37	.1040	.7280	1238.5	.31431	.02648
. .	350.000	37	.0973	.6811	1083.34	.27512	.03026
. .	300,000	19	.1256	.6285	926.01	.23591	.03531
. .	250,000	19	.1147	.5738	771.67	.19635	.04233
0000	211,600	19	.1055	.5275	653.14	.16609	.04997
000	167,772	19	.094	.4700	512.07	.13187	.06293
00	133,079	7	.1380	.4134	406.98	.10429	.07935
0	105,625	7	.1228	.3684	322.39	.08303	.10007
1	83,694	7	.1093	.3279	255.45	.06559	.12617
2	66,358	7	.0973	.2919	202.5	.05205	.15725
3	52,624	7	.0867	.2601	160.6	.04132	.19827
4	41,738	7	.0772	.2316	127.4	.03276	.25000
6	26,244	7	.0612	.1836	80.1	.02059	.39767
8	16,512	7	.0486	.1458	50.4	.01298	.62686
10	10,384	7	.0385	.1155	31.7	.00815	1.00848
12	6,528	7	.0305	.0915	19.9	.00511	1.59716
14	4,108	7	.0242	.0726	12.5	.00322	2.54192

Sizes of Wire for Rope Strands

General
Data

Capacity of Cable in Cir. Mils.	49 Wires 7 x 7	133 Wires 19 x 7	259 Wires 37 x 7	427 Wires 61 x 7	637 Wires 91 x 7
100000	.0452	.0274	.0197	.0153	.0125
125000	.0505	.0306	.0220	.0171	.0140
150000	.0553	.0336	.0242	.0188	.0154
175000	.0597	.0363	.0260	.0202	.0166
200000	.0638	.0388	.0278	.0216	.0177
225000	.0677	.0411	.0295	.0230	.0188
250000	.0714	.0435	.0311	.0242	.0198
275000	.0749	.0455	.0326	.0254	.0208
300000	.0783	.0475	.0341	.0265	.0217
325000	.0814	.0494	0354	.0276	.0226
350000	.0845	.0513	.0368	.0286	.0235
375000	.0875	.0531	.0381	.0296	.0243
400000	.0904	.0548	.0393	.0306	.0251
425000	.0931	.0565	.0405	.0315	.0259
450000	.0958	.0581	.0418	.0324	.0266
475000	.0984	.0598	.0428	.0333	.0273
500000	.1010	.0613	.0439	.0342	.0280
525000	.1035	.0628	.0450	.0350	.0287
550000	.1059	.0643	.0461	.0359	.0294
575000	.1083	.0658	.0472	.0367	.0301
600000	.1107	.0672	.0483	.0375	.0307
625000	.1129	.0686	.0492	.0383	.0313
650000	.1152	.0699	.0501	.0390	.0319
675000	.1174	.0712	.0510	.0398	.0325
700000	.1195	.0726	.0520	.0405	.0331
725000	.1216	.0738	.0529	.0412	.0337
750000	.1237	.0751	.0538	.0419	.0343
775000	.1258	.0763	.0546	.0426	.0349
800000	.1278	.0776	.0556	.0433	.0354
825000	.1297	.0788	.0565	.0440	.0360
850000	.1317	.0799	.0574	.0446	.0365
875000	.1336	.0811	.0583	.0453	.0371
900000	.1355	.0822	.0591	.0459	.0376
925000	.1374	.0834	.0599	.0466	.0381
950000	.1392	.0845	.0606	.0472	.0386
975000	.1411	.0856	.0614	.0478	.0391
1000000	.1429	.0867	.0621	.0484	.0396
1100000	.1498	.0909	.0652	.0508	.0416
1200000	.1565	.0951	.0683	.0530	.0434
1250000	.1597	.0969	.0695	.0541	.0443
1300000	.1627	.0988	.0708	.0552	.0452
1400000	.1690	.1026	.0735	.0573	.0469
1500000	.1750	.1062	.0761	.0593	.0485
1600000	.1807	.1096	.0786	.0612	.0501
1700000	.1862	.1130	.0811	.0631	.0517
1750000	.1889	.1147	.0823	.0640	.0525
1800000	.1916	.1162	.0836	.0649	.0532
1900000	.1969	.1196	.0857	.0667	.0546
2000000	.2020	.1226	.0878	.0685	.0560

The Manufacture of Wire

The metals used, almost to the exclusion of all others, for the conduction of electrical currents are, as before stated, copper and steel. It will not be out of place to give here some account of the method of winning these metals from their ores, the subsequent processes for their purification, and a short description of the means employed for giving the purified metals their final shape for use in electrical apparatus.

Copper

Copper is by far the most important material for conductors, both on account of its high conductivity and on account of its physical characteristics. Standing, as it does, next to silver, the best conductor, occurring in such quantities as to make its

General Data

supply adequate to the demand, and necessitating a fairly inexpensive though complex process for recovery, it is only natural that copper should have met with the greatest favor, and that the increase in its use should have been phenomenal. In fact, the wonderful growth and development in electrical apparatus have been made possible chiefly by the fact that we have two such metals as copper and iron, which possess the necessary conductivities for electricity and magnetism.

We find the ores of copper occurring in many and varied forms and widely distributed over the earth. In the United States there are three localities in which the copper mineralization is of considerable magnitude. The most important districts, in which about 95 per cent. of the total copper ore of the country is mined, are the Lake Superior region and the deposits of the Rocky Mountains and the Sierra Nevadas.

The Lake district is one of the most interesting localities, mineralogically speaking, in the world. The copper bearing rocks are very distinctly stratified beds of trap, sandstones and conglomerates which rise at an angle of about 45 degrees from the horizontal sandstone which forms the basin of Lake Superior. One peninsula extending out into the lake has developed copper in profitable amounts, which is present here for the most part in the metallic state, almost chemically pure.

The amount of copper in these ores averages only about 3 per cent., the balance being rock, which is so intimately mixed with the metal that both must be taken out together. On account of this large amount of worthless matter, the ores are first subjected to a mechanical process whereby the metal is concentrated into a small bulk and the rock rejected. "Lake" copper is so pure that it is merely put through the final melting without the refining usually necessary.

The deposits in the Rocky Mountains and the Sierra Nevadas comprise a territory nearly one-half the area of the United States, and in geological formations and nature of mineralization show all the phases from the original unaltered sulphide deposits to the most highly altered oxides and carbonates. In this district we find the mystery-shrouded names of Butte, Bisbee, Leadville, Clifton, Globe and Black Range, names which have spelled fortune or despair, rejoicing or suffering, to the thousands of prospectors who have discovered and rediscovered their wonderful richness.

The third and least important district is that of the Atlantic Coast beds. From the far north latitudes to Florida there extends an almost unbroken chain of mineralization, profitable at some locations, and bearing only traces of metallic deposits at others. In the North, where the earth's surface is comparatively new, having only yesterday, as it were, been shaved by a glacier, the minerals are in their original sulphide form. In the more southern portions, however, where this glacial abrasion has not taken place, and the oxidation and weathering of the surface has continued for no one knows how many centuries, the ore has been almost entirely decomposed and washed out from the surface. The result of this is that at greater depths the deposits are at times enormously enriched and concentrated. At a little greater depth, however, this concentration is lost and at times a meager vein with only traces of copper destroys all hope of profitable operation, and adds one more to the list of abandoned mines.

On account of the extremely low percentage of copper in most of its ores, the usual method of procedure, as we have seen, is to first obtain this metallic portion in as small a bulk as possible. This is a mechanical process and results in concentrating the heavy minerals, and washing away, or otherwise separating the worthless

General Data

rocky portion, or "gangue" as it is called. The "concentrates" resulting from this process are afterward treated to obtain the copper in the same manner as an ore.

A "sulphide ore," that is, an ore in which copper appears in chemical combination with sulphur, is in some cases first "roasted" or heated so that the sulphur is burned off, leaving the copper and iron, which is almost always present, in an oxidized or burned form. This is then smelted with coke. In another process, however, the raw sulphide ore is thrown into a blast furnace and is made to smelt itself. This is one of the very simple discoveries that have meant so much to the copper industry. Formerly a copper mine had a dozen or more great smouldering heaps piled up in its yard, breathing out clouds of stifling sulphur fumes. Nothing would grow for miles around, the men themselves had a white, bleached-out appearance, and besides, thousands upon thousands of dollars worth of precious fuel was being wasted. This has all been changed, the "raw" unroasted ore is now thrown into the furnaces, the sulphur itself burned and made to smelt the mass, producing, on account of its chemical nature, a highly impure, yet very valuable, compound with iron and sulphur, called "matte." This "matte" which consists of about half copper is poured while yet molten from the furnace into a "converter," a large vessel shaped like a barrel laid on its side, and the iron and sulphur are burned out by blowing through great volumes of air. Here again the despised and hated element, sulphur, by burning and generating heat, has made possible one of the most labor and time saving processes known to the metallurgy of copper. The result of this operation is "blister" copper, so called on account of the blistered appearance of the surface caused by the quantities of gases absorbed by the metal.

If copper ore occurs in an oxidized or carbonate form, or roasted ore is used, a blast furnace is also utilized for the reduction. Oxidized or sulphide ores are also often mixed and the matte is "blown" and blister copper produced as before.

This blister copper contains about 99 per cent. of copper but is much too impure for commercial use. The refining now depends upon whether the copper has a sufficient amount of the precious metals to pay for utilizing the electrolytic process. If so, the blister copper is cast into plates of a suitable size and shape, and the copper is dissolved and deposited almost chemically pure on other plates by means of an electric current passing through an acid solution of copper sulphate. The impurities and other metals do not deposit with the copper, but are dropped as a residue or "slime" on the bottom of the tank, to be recovered and refined later.

The blister copper or "electrolytic" copper, as the case may be, is then charged into a refining furnace and melted by means of a very pure fuel, so that the metal may not occlude any deleterious gases. A charge of 12 to 20 tons of pig copper is put in the furnace—a simple bowl-shaped hearth, covered and provided with doors for skimming and stirring—and the metal is melted as quickly as possible. The process is now one which depends greatly upon the skill of the refiner. After the metal is melted, and the last traces of sulphur have been removed by combination with the oxygen from the flame, the process known as "rabbling" or "flapping" is begun. This is a violent agitation of the metal by means of small rabbles or pokers through one of the side doors. This motion so far has not been duplicated mechanically, and it means a tedious and slow operation of about two hours' duration. During the flapping, samples are frequently taken in a hemispherical mould about an inch in diameter. When the "set" or appearance of the solidified metal in this mould indicates that sufficient work has been done upon it, the surplus oxygen must be removed to prevent the extreme brittleness and lack of conductivity of an over-oxidized metal. This is done by "poling" the bath. A stick of green hardwood as large as possible is introduced into the bath. The stick burns and the metal is

General Data

violently agitated by the gases given off. The surface of the bath is covered with charcoal to prevent further oxidation, and samples are very frequently taken. This is continued an hour, more or less, according to the size of the bath and the amount of oxidation, until the test piece shows "tough pitch" or the removal of the excess of oxygen, and that the metal is in its toughest condition. This "tough pitch" condition is absolutely essential for the requirements of rolling and wire drawing, as copper in this state possesses at the same time the highest degree of conductivity and an extremely tough and ductile nature. The metal is now poured into ingot-moulds or wire bars, in which condition it comes to our works for conversion into all manner of sizes and shapes for electrical conductors.

Copper Billets

The refining of copper and its separation from the multitude of alloying metals is a complex metallurgical process, but a very necessary one. Even traces of

General Data

other metals affect the conductivity to a remarkable degree, as the following table will show:

Element	Per Cent. Present in Copper	Per Cent. Conductivity
Carbon	0.05	77.87
Sulphur	0.18	92.08
Arsenic	0.10	73.89
Silver	1.22	90.34
Tin	1.33	50.44
Aluminum	0.10	86.49

With these figures in mind it is not difficult to appreciate why copper must be of the highest degree of chemical purity to be suitable for electrical conductors.

Iron and Steel

The distribution of iron ores follows in a general way that of copper. Here again the wonderfully mineralized Lake Superior region plays an important part in the supply, statistics showing that the states of Michigan, Wisconsin and Minnesota produced in 1908 over 78 per cent. of the total ore mined in the United States. The Southern states, Alabama, the Virginias, Tennessee, Kentucky, Georgia, Maryland and North Carolina contributed about 12 per cent. of the country's supply. The balance is distributed quite widely along the Atlantic Coast range, the Mississippi Valley and Rocky Mountains.

The separation of the metal from an iron ore is a much simpler problem in some respects than that which we considered in the case of copper. Practically all of the ores commercially utilized are already in an oxide or carbonate combination so that a simple heating to the reducing point of the ore in contact with a proper reducing material is sufficient to bring about the first step in the process.

The ore, as mined, consists exactly as in the case of copper, of two main constituents, the valuable mineral which contains the iron, and quantities of rock and other materials from which the metallic part must be separated. With copper ores we can at times mechanically concentrate the metallic portions as we have already seen, but with an iron ore that is usually not feasible, the ore being charged as a whole into the furnace, and the proper mixing with non-metallic substances relied upon to form final products which are easily fusible, and from which the liquid iron will separate itself by reason of its greater specific gravity. The "flux," as these additions are called, is usually limestone, as the gangue is usually of a silicious nature.

The ore, fuel and fluxes are charged into a blast furnace. This is a huge cylindrical stack 80 to 100 feet high and about 20 feet in diameter at its largest point, with suitable arrangements for blowing in great volumes of air near its base. The fuel used is coke, which heats the charge up to its melting point and at the same time frees the iron from its chemical bonds in the ore. The earthy portions of the ore are eargerly sought for by the limestone and unite with it to form a waste product, the slag. The carbon in the coke singles out the iron in combination with oxygen and in a brief moment destroys the associations of hundreds of thousands of years and starts the iron on its path toward its destination, which may be a part

General Data

of some noble structure, a rail upon whose soundness many lives may depend, a wire whose message may bring joy or sorrow, or any of the innumerable products of this the "Iron Age."

A Typical Michigan Iron Ore Mining Scene

The metal from these furnaces is called "pig iron" and is employed mainly in this shape as a stepping stone toward other products. The selection of our material is begun when the ore is mined. The various grades of ore, each differing from the others in some essential characteristic, are mixed carefully according to proportions which are the result of long years of experience ; the resulting pig iron is carefully graded and the proper grades carefully preserved for making such grades of steel as are required for the manufacture of wire.

The next step is the conversion of the "pig" into shape for the manufacture of wire. The pig itself is coarse-grained, brittle and full of impurities, which must be removed before we can obtain the metal in a condition suitable for wire. This is done by melting the pig in mixture with steel scrap of a highly selected grade and subjecting the molten mass to the purifying action of an intensely hot flame. After several hours, in which the various impurities are literally "boiled out," the metal is poured into a huge flat bottomed "ladle" and thence through a small hole in the bottom of the ladle. The liquid stream pours into cast-iron moulds, which shape it into ingots nearly a foot and a half square and six feet tall. These ingots are taken out of the mould after the outside has firmly solidified and are plunged into a deep, white-hot abyss in which they "soak" until the temperature is uniform throughout. After this soaking an immense crane seizes an ingot in its vise-like grip and carries it to the rolling mill, where the mechanical operations commence.

The first series of operations takes place on what is called a "blooming mill," the resulting products of which are styled "blooms." Here the ingot is passed back and forth between heavy chilled steel rolls, each pass elongating the ingot and making its section smaller. Back and forth this goes, turned like a stick of wood by the wonderful mechanical fingers of the mill until the particular size desired is reached. In our case, the metal has been squeezed in and out, through and through, until the section has been reduced to four inches square and the length increased from six feet to over one hundred. This long mass is now cut into pieces about four feet long, which have become so cool that they must be reheated before reducing the size further.

Steel Billets

From this point on, the treatment of copper and these blooms is practically the same. The copper wire bars are received in approximately the same size and length and are heated to a cherry redness in the same furnaces.

Through roll after roll, each doing its share toward reducing their sizes, the billets pass in succession; as the size grows less the speed increases and the rod elongates until finally our stubby bloom four feet long has produced a rod which may be a quarter of an inch in diameter and nearly a quarter of a mile in length.

Up to this point the metal has been handled hot, but during the processes of wire drawing it is worked in the cold state. The first step after the rod has left the rolling mill and has cooled down, is to immerse it in a weak solution of sulphuric acid to take off the scale which has formed on the rod while it was cooling in the air. This done, the rods are washed in a stream of high pressure water and dipped into a vat of lime which coats them and prevents rusting. They are now "baked out" in huge ovens to counteract the ill effects of the acid bath, and are then in proper condition for drawing.

Wire Drawing

The drawing process consists, briefly, in reducing the diameter of the wire by pulling it through tapering holes in iron or steel plates, thus reducing its diameter and increasing its length with each draft until the wire has undergone a sufficient number of drafts and consequent reductions to bring it to the proper diameter.

When the finer sizes of wire are to be produced, the total reduction cannot be made in one series of drafts, as we are limited in the size of a hot-rolled rod, and the wire therefore must be treated at intervals to relieve the internal strains produced by the cold working. This treatment, called annealing, consists in heating the metal uniformly to a sufficiently high temperature to remove the internal molecular strains and to make the metal once more soft and ductile.

A scale forms on the wire as a result of the annealing. This is again removed in an acid bath, and the wire limed and baked and sent to the drawing frames. This may be repeated many times before the necessary amount of reduction has been attained.

Copper is generally handled somewhat differently in the annealing process, as precautions are taken to prevent the formation of scale. Especially is this true in the case of fine magnet wires, for instance, where oxidation would seriously affect the properties of the wire. This is done by "bright annealing," which is accomplished in various ways by preventing the metal, while it is at a high temperature, from coming in contact with the air. By this means we obtain an annealed wire as bright as when it comes from the drawing frames. So the process goes, drawing as far as feasible, annealing and drawing again until the finest sizes of magnet wire are finally produced, by drawing through holes skillfully drilled in diamonds.

As the physical condition of the wire depends largely upon the number and amount of the drafts, the proper regulation of these to produce the best results, especially in the case of hard drawn copper, requires much study and long experience. Many drafts, each giving only a slight reduction, produce an entirely different effect from few drafts, even though the ultimate reduction in area be the same. Drawing the same size of wire on blocks of different diameters will vary the physical characteristics. Various methods of annealing will produce various results, and so on. There is a multitude of details, each of which has its own effect.

Cold drawing or cold rolling a rod or annealed wire invariably increases its hardness, stiffness, elasticity and tensile strength and at the same time decreases its elongation, ductility and electrical conductivity. The amount of these changes, however, is not directly proportional to the per cent. of reduction in sectional area or to the amount of work expended on the metal. Statements have been made to the contrary, but our many experiments and careful observations have established beyond a doubt the accuracy of the foregoing. The actual change in the physical properties of a wire by cold working are affected by many factors, as we have already stated, and the final effect is difficult to forecast; hence long experience with these problems is exceedingly valuable both to the maker and to the user of wire.

The tensile strength and elongation of wire vary considerably with its size. Annealed or soft copper wire varies in tensile strength from 30,000 pounds per square inch in the coarser sizes to 42,000 pounds in the fine sizes. Hard drawn copper varies in tensile strength from 45,000 to 68,000 pounds per square inch, according to size.

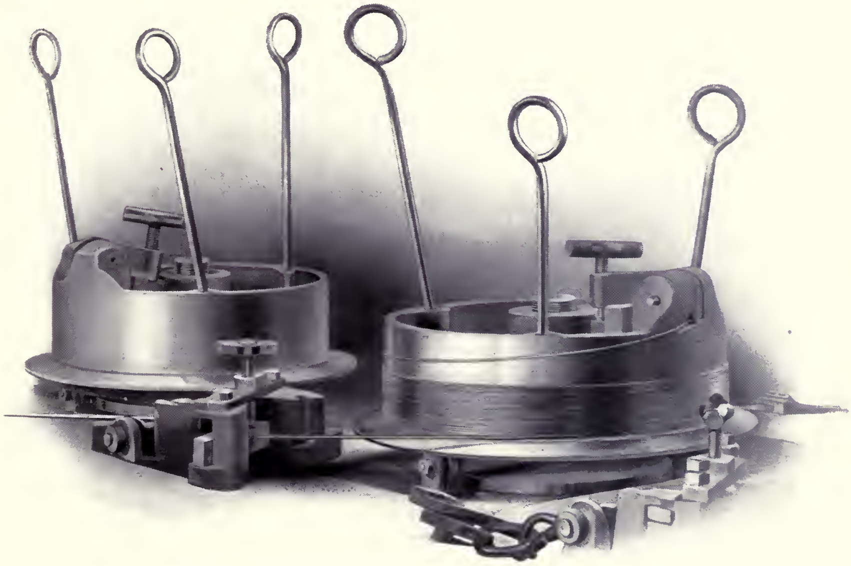
General Data

The elongation also varies according to size, as a ten-inch length will show 45 per cent. in coarse wire, while a fine wire will elongate only about 15 per cent. in the same length. The per centum elongation obtained depends very largely upon the length of test specimen, the highest elongation being obtained in the shortest length. To illustrate: a 12-inch linear section of annealed copper wire, 600 mils in diameter, will elongate about 45 per cent. The elongation occurring in shorter sections of the same specimen will be approximately as follows:

Elongation of Annealed Copper Wire

Diameter in Mils	Per Cent. Elongation Calculated on Measured Length of							
	12 Inches	10 Inches	8 Inches	6 Inches	4 Inches	3 Inches	2 Inches	1 Inch
600	45	46	48	50	53	58	63	75

The foregoing fact of a variable elongation dependent upon the length of test specimen is equally true of hard drawn wire. While the figures for hard wire differ widely from those for soft wire, the proportionate variation in elongation of hard wire due to length of test specimen is even greater than for soft wire. This is illustrated by the following figures, which are approximately correct for 2/0 B. & S. hard copper trolley wire and for No. 4 B. & S. hard drawn copper wire.



Drawing Wire Through a Die

General Data

Elongation of Hard Drawn Copper Wire

Size B. & S.	Diameter in Mils	Per Cent. Elongation Calculated on Measured Length of							
		12 Inches	10 Inches	8 Inches	6 Inches	4 Inches	3 Inches	2 Inches	1 Inch
00	364.8	4.0	4.5	5.0	6.0	7.5	10.0	13.0	22.0
4	204.3	1.8	2.1	2.4	3.0	4.0	5.2	7.2	12.0

This fact is of considerable importance in drawing up specifications, as it is readily seen that a specified elongation is of little value unless the measured length is given.

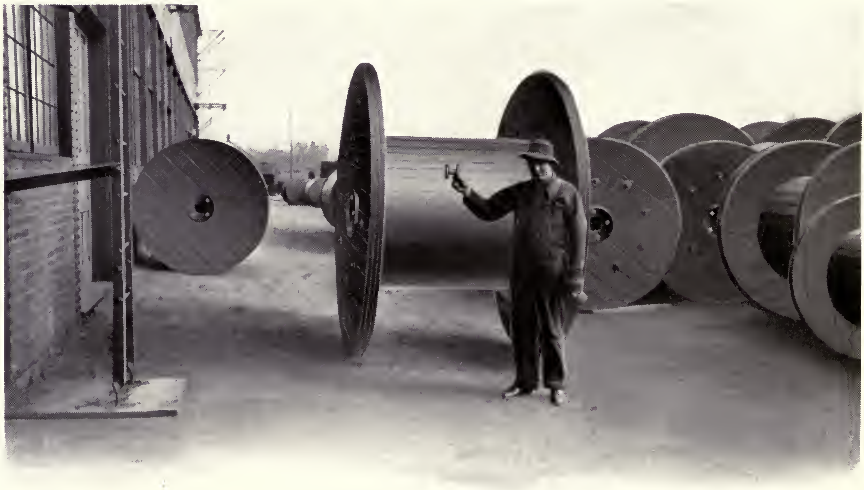
Tinning and Galvanizing Wire

Copper conductors are often tinned and telegraph wire is usually galvanized. The methods of supplying these coatings while simple to describe are nevertheless in actual performance complex, requiring careful supervision and expert workmanship.

The principle of the process is to pass a wire first through a tank of acid whose function is to clean the wire, next through a water tank where the acid is washed off, next through a flux, and then into the molten tin or zinc. It is not hard to get the tin or zinc to adhere over almost all of the surface, but the absolute perfection demanded by the trade requires that every portion of the wire must be covered with a uniform thickness of metal which must be bright and which will not peel or crack. This has justified the elaborate equipment and painstaking operation employed in maintaining the quality of our product.

Packing and Shipping

Many can no doubt remember the time when neither the manufacturer nor the purchaser gave any particular attention as to how goods were packed or shipped so long as they arrived at their destination in comparatively good condition. But these conditions have changed steadily within the past few years, and to-day practically all complete and up-to-date specifications make special mention of the



method of packing and shipping. We have, after many years of careful attention to this subject, developed a system which is very complete in all details, having made use of data accumulated from all kinds and conditions of shipments, from the smallest spool of delicate silk covered magnet wire of only a few ounces in weight, to the largest reel of aerial, underground or submarine cables of many tons weight, to destinations near by or to remote points in foreign countries.

General Data

Coils of Wire

It is necessary that wire be properly coiled to prevent snarling and other difficulties.

Our coils are formed to standard dimensions, evenly wound and securely bound with strong and durable material, both ends of the coil being accessible for test purposes and only one length in a coil, unless otherwise specified. These coils are protected by paper or burlap, or both if conditions require it. The covering materials are selected for the purpose, cut to proper dimensions so as to protect the wire in the most complete way, without giving a surplus amount of material which would increase the tare weight. All wires are inspected when being wound into coils and also at the time of papering or burlapping. Each individual coil is papered or burlapped by hand, which gives a good opportunity to detect any visible mechanical defects. All coils are accurately measured or weighed before shipment, and properly tagged with strong, durable tags on which are given full details.

General Data

The size of the coil is arranged so as to be most convenient for handling, packing or shipping, according to the kind and size of wire in the coil. We ship coils according to the customer's requirements, packed in boxes or barrels and so arranged in these that there will be no unnecessary waste space; or they may be shipped loosely in carload lots when specified. All large coils are protected with paper and burlap and are generally shipped loose.

Stringing Wire from Coils

When wire is purchased for the purpose of stringing on poles, the general impression is that it is easier to handle if placed on reels than in coils; but if this question were given a little thought, we believe that persons having such an idea would be convinced otherwise. They should take into consideration the transportation of wire in coils as against wire on reels, the increased amount of coiled wire that can be stored in a given space as compared with the same amount placed on reels; the increased cost of freight, due to weight of reels, the necessity of keeping

Wrapping Coils

Stringing Heavy Wire from Coils

General Data

reels in good condition after being emptied, the amount of handling incurred because of empty reels, return transportation charges and the necessary clerical work and supervision required. With coils, all labor and responsibility cease after the wire is strung. We do not recommend coiling solid wire that is larger than 1/0 B. & S. gauge, except in special cases.

A suitably constructed blade, such as shown on the previous page, will fit any standard coil. With the lead arm and swivel sheave it makes the uncoiling of the wire during process of stringing on poles or other places a very economical and easy process, and avoids the possibility of snarls, provided the coil is properly placed upon the blade. With this lead arm and sheave, the wire may be drawn over a cross-arm on a pole, when the coil is almost directly under the cross-arm, if lack of space requires this to be done. This system of handling wire also reduces the amount of apparatus that would be required for operating reels, such as bars, jacks, and so on. Blades of similar construction can be placed on any ordinary wagon, and, with the exception of lifting coils of the largest sizes of wire, one man, usually the teamster, can operate the uncoiling of wire. After finishing the day's work of stringing wire by the coil method, there are no empty reels to be collected, cared for and returned to the manufacturer, and no credit to be looked out for.

Standard Dimensions of Coils

Solid Copper Weatherproof Wire

Size B. & S.	Approximate Weight per Coil, Pounds		Approximate Outside Diameter of Coil Inches	Approx. Diameter of Eye of Coil Inches	Approx. Thickness of Coil Inches	Covering of Coil	How Shipped
	2 Braids	3 Braids					
0000	360	383	30 to 34	19	7½	Paper and Burlap	Loose Coils
000	352	377	30 to 34	19	7½		
00	326	350	30 to 34	19	7½		
0	301	325	30 to 34	19	7½		
1	294	316	30 to 34	19	7½		
2	310	338	30 to 34	19	7½		
3	305	330	30 to 34	19	7½		
4	317	344	30 to 34	19	7½		
5	317	350	30 to 34	19	7½		
6	320	180	30 to 34	19	6		
8	171	195	30 to 34	19	6		
10	50	50	18 to 20	12	5	Paper	Coils Packed in Barrels
12	40	40	18 to 20	12	5		
14	40	40	18 to 20	12	5		
16	30	30	18 to 20	12	5		
18	30	30	18 to 20	12	5		

Weatherproof Iron Wire

Size B. W. G.	Approx. Weight per Coil Pounds		Approx. Outside Diameter of Coil Inches	Approx. Diameter of Eye of Coil Inches	Approximate Thickness of Coil Inches		Covering of Coil	How Shipped	Length in a Coil Feet
	2 Braids	3 Braids			2 Braids	3 Braids			
6	222	247	30 to 34	19	6	7½	Paper and Burlap	Loose Coils	1760
8	235	263	30 to 34	19	6	7½			2640
9	200	225	30 to 34	19	6	7½			2640
10	175	200	30 to 34	19	6	7½			2640
12	113	130	30 to 34	19	6	7½			2640
14	78	87	22 to 24	12	5	5			2640

Standard Dimensions of Coils—Continued

Slow-burning Wire

Size B. & S.	Approx. Weight per Coil Pounds	Approx. Outside Diameter of Coil Inches	Approx. Diameter of Eye of Coil Inches	Approx. Thickness of Coil Inches	Covering of Coil	How Shipped
8	50	18 to 20	12	5	Paper	Loose Coils Packed in Barrels
10	40	18 to 20	12	5		
12	55	18 to 20	12	5		
14	40	18 to 20	12	5		
16	30	18 to 20	12	5		
18	24	18 to 20	12	5		

Lamp Cords

Unless otherwise ordered this material is always shipped in approximately 250 feet coils wrapped with paper and packed in boxes containing either 1000 feet or 1000 yards (3000 feet), as ordered.

Rubber Insulated and Braided Wire

No. 6 and finer single conductor rubber insulated and braided wires are shipped in approximately 500-foot coils, having a 12-inch eye, wrapped in paper, and packed in boxes or barrels, unless otherwise specified.

No. 10 and finer duplex parallel rubber insulated and braided are shipped in approximately 500-foot coils, having a 12-inch eye, and in other respects the same as the single conductor.

No. 12 and finer twisted pair rubber insulated and braided are shipped in approximately 500-foot and 1000-foot coils, and in other respects the same as the single conductor.

Wooden Reels

The reels used for shipping electric wires and cables are so constructed as to give the greatest protection to this class of material. We have on hand at all times a large supply of the different kinds and sizes of reels, as shown in the following table. These reels are always kept in good repair and can be supplied at a very short notice. The various sizes of reels are numbered for convenience in distinguishing them.

Material put on the reel is so arranged as to give the customer the least inconvenience in handling. The kind and size of wire to be shipped governs the size of the reel to be used.

Careful attention is always paid to the diameter of the barrel selected so that cables will not be bent to a diameter which would in any way injure the cable. Reels are never loaded to their full capacity, for we consider it advisable to allow a few inches clearance between the rim of the reel and the cables to prevent any possibility of damage to the wire when the reels are rolled about. All large reels before shipment are lagged with strong and durable strips of wood of suitable dimensions, in accordance with the size of reel. The wire on spools or small reels is protected by paper, burlap, or sheet iron.

General Data

Standard Dimensions of Reel Lagging

⅞ x 2 x 11 inches
⅞ x 2 x 16 inches
⅞ x 2 x 20¼ inches
2 x 4 x 27¼ inches
2 x 4 x 29 inches
2 x 4 x 35 inches
2 x 4 x 37¼ inches
2 x 4 x 41 inches
2 x 4 x 50 inches
2 x 4 x 56 inches
2 x 4 x 63½ inches
2 x 4 x 70 inches
2 x 4 x 76 inches

Lagging is made from well seasoned lumber, free from knots, having in view the minimum possibility of breaking. Reels and spools for magnet wire are specially made for this particular product and are so designed and constructed as to give the best protection to the delicate grade of wire which they hold.

Standard Shipping Reels for Electrical Wires and Cables

List No. Burned in Head of Reel	Symbol	Dimensions are given in Inches					Average Weight in Pounds	Price per Reel
		Diameter of Head	Diameter of Barrel	Width Inside	Width Outside	Arbor Hole		
302	W	30.	14.	8.	11.50	1.125 ○	43.	$2.00
304	A	3.25	1.	3.75	5.125	.375 ○	.312	. .
305	A	2.75	1.	3.	4.375	.375 ○	.218	. .
306	A	6.	1.375	3.1875	4.0625	.625 ○	.5	. .
313	M	22.	15.	6.	9.50	1.375 ○	22.	1.50
315	W	38.	16.	22.50	27.75	1.625 ○	165.	5.00
316	W	32.	16.	14.50	19.75	1.625 ○	93.	5.00
321	M	28.	22.	6.	9.50	1.375 ○	37.	2.00
322	W	30.	12.	11.	14.50	1.125 ○	50.	2.00
324	W	60.	28.	32.	38.25	2.625 ○	500.	10.00
330	W	44.	24.	23.	27.	2.625 ○	190.	4.00
333	W	50.	28.	32.	37.25	2.625 ○	340.	10.00
334	R	36.	24.	11.	16.25	1.625 ○	102.	4.00
335	R	36.	24.	15.	20.25	1.625 ○	115.	5.00
336	R	58.	38.	35.	40.75	2.625 ○	430.	12.00
338	M	13.50	6.	5.	6.50	1.125 ○	5.7	0.75
341	M	24.	15.	6.50	9.50	1.375 ○	24.	2.00
342	M	24.	15.	6.50	9.50	1.375 ○	29.	2.00
343	M	7.	2.375	2.75	3.75	.625 ○	.95	. .
344	M	22.	15.	5.75	9.25	1.375 ○	22.	2.00
345	M	3.50	1.375	2.75	3.75	.625 ○	.25	. .
347	M	4.50	1.75	2.75	3.75	.625 ○	.33	. .
349	M	9.	4.50	4.	6.	1. ○	3.50	.40
350	M	12.	6.	5.	7.50	1.25 ○	7.50	.75
351	M	6.	2.375	2.75	3.75	.625 ○	.72	.20
352	Rope	28.	14.	13.50	17.	4. ○	51.	2.00
354	M	16.	8.	5.50	8.50	1.25 ○	15.	1.25
355	R	66.	42.	35.	41.25	2.625 ○	780.	15.00
356	A	3.75	1.	3.75	5.25	.375 ○	.50	.15
1002	R	42.	30.	24.	29.25	2.625 ○	205.	5.00
1004	R	30.	18.	8.	11.50	1.625 ○	45.	2.00
1013	R	48.	36.	24.	29.25	2.625 ○	262.	10.00
1015	R	66.	42.	35.	40.75	2.625 ○	510.	15.00
1020	R	54.	36.	30.	35.25	2.625 ○	320.	10.00
1021	R	62.	40.	35.	40.75	2.625 ○	465.	10.00
1022	R	63.	30.	45.	50.75	2.625 ○	600.	15.00
1023	R	76.	36.	45.	51.25	2.625 ○	1040.	15.00
1025	R	92.	48.	53.	63.50	7.25 ○,□	2140.	50.00
1026	R	80.	56.	48.	56.	7.25 ○,□	1600.	30.00
1027	R	96.	32.	59.	71.	7.25 ○,□	2400.	65.00
1028	R	72.	42.	42.	50.	7.25 ○,□	1490.	30.00
1029	R	104.	36.	64.	76.	7.25 ○,□	3650.	70.00

A=reels for annunciator wire.
R=reels for rubber, paper or cambric insulated wires and cables.
M=reels for magnet wire.
W=reels for weatherproof wires and cables.

These reels are well constructed and are expensive to make. They should be carefully handled. If promptly returned, with slats, and in good condition, they will be credited at the price quoted above, less transportation to our factory.

General Data

All reels and spools of magnet wire, when being prepared for shipment, are individually weighed, marked and labelled so that the customer will be able to determine the exact weight of each package of wire, no matter how small.

Packing Magnet Wire

One of the commonest ways of injuring insulated wires or cables is by putting them on reels of incorrect capacity. For the convenience of our readers who may have occasion to load reels, a safe formula for figuring the capacity of reels is given in the following:

Let d = diameter of cable in inches
C = minimum clearance in inches (2 inches ordinary)
B = diameter of barrel or reel
$D = \frac{1}{2}$ (diameter of head$-B-2C$) = radius of head less clearance, less radius of barrel; or available space from barrel to edge of head.
W = length of barrel.
Then L = number of layers
$= \frac{D}{d}$ (take largest whole number)
N = number of turns per layer
$= \frac{W}{d}$ (take largest whole number)
F = feet per reel with minimum clearance
$= .262 \times (B + D) \times NL.$

For example: To determine the number of feet of a cable 1.3 inches in diameter, that a No. 1002 reel will hold: Head of reel 42 inches in diameter, allowable clearance 2 inches. Barrel of reel 30 inches in diameter. Width between heads 24 inches, from table above.

$$D = \tfrac{1}{2}(42-30)-2 = 4;\ C = 2'';\ B = 30'';\ W = 24''$$

$$L = \frac{6-2}{1.3} = \frac{4}{1.3} = 3.+ \text{ or } 3 \text{ layers}$$

$$N = \frac{24}{1.3} = 18.+ \text{ or } 18 \text{ turns per layer}$$

$$F = .262 \times (30 + 4) \times 18 \times 3$$
$$= .262 \times 34 \times 18 \times 3 = 481 \text{ feet.}$$

General Data

Metric Weights and Measures

Linear

1 meter = 39.3704 inches = 3.281 feet = 1.094 yards.
Centimeter (1-100 meter) = 0.3937 inch.
1 millimeter (mm.) = .03937 inch = 39.37 mils.
1 inch = 25.3997 millimeters = .083 foot = 2.54 centimeters.
1 kilometer = 1,000 meters or 3,281 feet = .6213 mile.
For the purpose of memory, a meter may be considered as 3 feet 3⅓ inches.

Surface Measures

Centare (1 square meter) = 1,550 square inches = 10.764 square feet.
Are (100 square meters) = 119.6 square yards.
1 square centimeter = 0.155 square inch = 197,300 circular mils.
1 square millimeter = .00155 square inch = 1973 circular mils.
1 square inch = 6.451 square centimeters = .0069 square foot.
1 square foot = 929.03 square centimeters = .0929 square meter.

Weights

Milligram (1-1,000 gram) = 0.0154 grain.
Centigram (1-100 gram) = 0.1543 grain.
Decigram (1-10 gram) = 1.5432 grains.
Gram = 15.432 grains.
Decagram (10 grams) = 0.3527 ounce.
Hectogram (100 grams) = 3.5274 ounces.
Kilogram (1,000 grams) = 2.2046 pounds.
Myriagram (10,000 grams) = 22.046 pounds.
Quintal (100,000 grams) = 220.46 pounds.
Millier or tonne—ton (1,000,000 grams) = 2,204.6 pounds.

Volumes

Milliliter (1-1,000 liter) = 0.061 cubic inch.
Centiliter (1-100 liter) = 0.6102 cubic inch.
Deciliter (1-10 liter) = 6.1023 cubic inches.
Liter = 1,000 cu. cm. = 61.023 cubic inches.
Hectoliter (100 liters) = 2.838 bushels.
Kiloliter (1,000 liters) = 1,308 cubic yards.

Liquid Measures

Milliliter (1-1,000) = 0.0338 fluid ounce.
Centiliter (1-100 liter) = 0.338 fluid ounce.
Deciliter (1-10 liter) = 0.845 gill.
Liter = 0.908 quart = 0.2642 gallon.
Decaliter (10 liters) = 2.6418 gallons.
Hectoliter (100 liters) = 26.418 gallons.
Kiloliter (1,000 liters) = 264.18 gallons.

General Data

Conversion of Mils to Millimeters

Mils	Millimeters	Mils	Millimeters	Mils	Millimeters	Mils	Millimeters	Mils	Millimeters
1	.0254	21	.5334	41	1.0414	61	1.5494	81	2.0574
2	.0508	22	.5588	42	1.0668	62	1.5748	82	2.0828
3	.0762	23	.5842	43	1.0922	63	1.6002	83	2.1082
4	.1016	24	.6096	44	1.1176	64	1.6256	84	2.1336
5	.1270	25	.6350	45	1.1430	65	1.6510	85	2.1590
6	.1524	26	.6604	46	1.1684	66	1.6764	86	2.1844
7	.1778	27	.6858	47	1.1938	67	1.7018	87	2.2098
8	.2032	28	.7112	48	1.2192	68	1.7272	88	2.2352
9	.2286	29	.7366	49	1.2446	69	1.7526	89	2.2606
10	.2540	30	.7620	50	1.2700	70	1.7780	90	2.2860
11	.2794	31	.7874	51	1.2954	71	1.8034	91	2.3114
12	.3048	32	.8128	52	1.3208	72	1.8288	92	2.3368
13	.3302	33	.8382	53	1.3462	73	1.8542	93	2.3622
14	.3556	34	.8636	54	1.3716	74	1.8796	94	2.3876
15	.3810	35	.8890	55	1.3970	75	1.9050	95	2.4130
16	.4064	36	.9144	56	1.4224	76	1.9304	96	2.4384
17	.4318	37	.9398	57	1.4478	77	1.9558	97	2.4638
18	.4572	38	.9652	58	1.4732	78	1.9812	98	2.4892
19	.4826	39	.9906	59	1.4986	79	2.0066	99	2.5146
20	.5080	40	1.0160	60	1.5240	80	2.0320	100	2.5400

Conversion of Millimeters to Mils

Millimeters	Mils	Millimeters	Mils	Millimeters	Mils	Millimeters	Mils	Millimeters	Mils
1	39.370	21	826.77	41	1614.17	61	2401.57	81	3188.97
2	78.740	22	866.14	42	1653.54	62	2440.94	82	3228.34
3	118.110	23	905.51	43	1692.91	63	2480.31	83	3267.71
4	157.48	24	944.88	44	1732.28	64	2519.68	84	3307.08
5	196.85	25	984.25	45	1771.65	65	2559.05	85	3346.45
6	236.22	26	1023.60	46	1811.02	66	2598.42	86	3385.82
7	275.59	27	1063.00	47	1850.39	67	2637.79	87	3425.19
8	314.96	28	1102.40	48	1889.76	68	2677.16	88	3464.56
9	354.33	29	1141.70	49	1929.13	69	2716.53	89	3503.93
10	393.70	30	1181.10	50	1968.50	70	2755.90	90	3543.30
11	433.07	31	1220.50	51	2007.87	71	2795.27	91	3582.67
12	472.44	32	1259.80	52	2047.24	72	2834.64	92	3622.04
13	511.81	33	1299.20	53	2086.61	73	2874.01	93	3661.41
14	515.18	34	1338.60	54	2125.98	74	2913.38	94	3700.78
15	590.55	35	1378.00	55	2165.35	75	2952.75	95	3740.15
16	629.92	36	1417.30	56	2204.72	76	2992.12	96	3779.52
17	669.29	37	1456.70	57	2244.09	77	3031.49	97	3818.89
18	708.66	38	1496.10	58	2283.46	78	3070.86	98	3858.26
19	748.03	39	1535.40	59	2322.83	79	3110.23	99	3897.63
20	787.40	40	1574.80	60	2362.20	80	3149.60	100	3937.00

General Data

Areas and Circumferences of Circles

Diameter	Circumference	Area	Diameter	Circumference	Area	Diameter	Circumference	Area
1/64	.049087	.00019	1. 15/16	6.08684	2.9483	4. 15/16	15.5116	19.147
1/32	.098175	.00077	2.	6.28319	3.1416	5.	15.7080	19.635
3/64	.147262	.00173	1/16	6.47953	3.3410	1/16	15.9043	20.129
1/16	.196350	.00307	1/8	6.67588	3.5466	1/8	16.1007	20.629
3/32	.294524	.00690	3/16	6.87223	3.7583	3/16	16.2970	21.135
1/8	.392699	.01227	1/4	7.06858	3.9761	1/4	16.4934	21.648
5/32	.490874	.01917	5/16	7.26493	4.2000	5/16	16.6897	22.166
3/16	.589049	.02761	3/8	7.46128	4.4301	3/8	16.8861	22.691
7/32	.687223	.03758	7/16	7.65763	4.6664	7/16	17.0824	23.221
1/4	.785398	.04909	1/2	7.85398	4.9087	1/2	17.2788	23.758
9/32	.883573	.06213	9/16	8.05033	5.1572	9/16	17.4751	24.301
5/16	.981748	.07670	5/8	8.24668	5.4119	5/8	17.6715	24.850
11/32	1.07992	.09281	11/16	8.44303	5.6727	11/16	17.8678	25.406
3/8	1.17810	.11045	3/4	8.63938	5.9396	3/4	18.0642	25.967
13/32	1.27627	.12962	13/16	8.83573	6.2126	13/16	18.2605	26.535
7/16	1.37445	.15033	7/8	9.03208	6.4918	7/8	18.4569	27.109
15/32	1.47262	.17257	15/16	9.22843	6.7771	15/16	18.6532	27.688
1/2	1.57080	.19635	3.	9.42478	7.0686	6.	18.8496	28.274
17/32	1.66897	.22166	1/16	9.62113	7.3662	1/8	19.2423	29.465
9/16	1.76715	.24850	1/8	9.81748	7.6699	1/4	19.6350	30.680
19/32	1.86532	.27688	3/16	10.0138	7.9798	3/8	20.0277	31.919
5/8	1.96350	.30680	1/4	10.2102	8.2958	1/2	20.4204	33.183
21/32	2.06167	.33824	5/16	10.4065	8.6179	5/8	20.8131	34.472
11/16	2.15984	.37122	3/8	10.6029	8.9462	3/4	21.2058	35.785
23/32	2.25802	.40574	7/16	10.7992	9.2806	7/8	21.5984	37.122
3/4	2.35619	.44179	1/2	10.9956	9.6211	7.	21.9911	38.485
25/32	2.45437	.47937	9/16	11.1919	9.9678	1/8	22.3838	39.871
13/16	2.55254	.51849	5/8	11.3883	10.321	1/4	22.7765	41.282
27/32	2.65072	.55914	11/16	11.5846	10.680	3/8	23.1692	42.718
7/8	2.74889	.60132	3/4	11.7810	11.045	1/2	23.5619	44.179
29/32	2.84707	.64504	13/16	11.9773	11.416	5/8	23.9546	45.664
15/16	2.94524	.69029	7/8	12.1737	11.793	3/4	24.3473	47.173
31/32	3.04342	.73708	15/16	12.3700	12.177	7/8	24.7400	48.707
	3.14159	.78540	4.	12.5664	12.566	8.	25.1327	50.265
1/16	3.33794	.88664	1/16	12.7627	12.962	1/8	25.5254	51.849
1/8	3.53429	.99402	1/8	12.9591	13.364	1/4	25.9181	53.456
3/16	3.73064	1.1075	3/16	13.1554	13.772	3/8	26.3108	55.088
1/4	3.92699	1.2272	1/4	13.3518	14.186	1/2	26.7035	56.745
5/16	4.12334	1.3530	5/16	13.5481	14.607	5/8	27.0962	58.426
3/8	4.31969	1.4849	3/8	13.7445	15.033	3/4	27.4889	60.132
7/16	4.51604	1.6230	7/16	13.9408	15.466	7/8	27.8816	61.862
1/2	4.71239	1.7671	1/2	14.1372	15.904	9.	28.2743	63.617
9/16	4.90874	1.9175	9/16	14.3335	16.349	1/8	28.6670	65.397
5/8	5.10509	2.0739	5/8	14.5299	16.800	1/4	29.0597	67.201
11/16	5.30144	2.2365	11/16	14.7262	17.257	3/8	29.4524	69.029
3/4	5.49779	2.4053	3/4	14.9226	17.721	1/2	29.8451	70.882
13/16	5.69414	2.5802	13/16	15.1189	18.190	5/8	30.2378	72.760
7/8	5.89049	2.7612	7/8	15.3153	18.665	3/4	30.6305	74.662

Decimals of an Inch and Millimeters for each 1-64 Inch

1/32 In.	1/64 In.	Decimal Inch	Decimal mm.	Fraction	1/32 In.	1/64 In.	Decimal Inch	Decimal mm.	Fraction	1/32 In.	1/64 In.	Decimal Inch	Decimal mm.	Fraction	1/32 In.	1/64 In.	Decimal Inch	Decimal mm.	Fraction
	1	.015625	.3968			17	.265625	6.7467			33	.515625	13.0966			49	.765625	19.4465	
1	2	.03125	.7937		9	18	.28125	7.1436		17	34	.53125	13.4934		25	50	.78125	19.8433	
	3	.046875	1.1906			19	.296875	7.5404			35	.546875	13.8903			51	.796875	20.2402	
2	4	.0625	1.5874	1/16	10	20	.3125	7.9373	5/16	18	36	.5625	14.2872	9/16	26	52	.8125	20.6371	13/16
	5	.078125	1.9843			21	.328125	8.3342			37	.578125	14.6841			53	.828125	21.0339	
3	6	.09375	2.3812		11	22	.34375	8.7310		19	38	.59375	15.0809		27	54	.84375	21.4308	
	7	.109375	2.7780			23	.359375	9.1279			39	.609375	15.4778			55	.859375	21.8277	
4	8	.125	3.1749	1/8	12	24	.375	9.5248	3/8	20	40	.625	15.8747	5/8	28	56	.875	22.2245	7/8
	9	.140625	3.5718			25	.390625	9.9216			41	.640625	16.2715			57	.890625	22.6214	
5	10	.15625	3.9686		13	26	.40625	10.3185		21	42	.65625	16.6684		29	58	.90625	23.0183	
	11	.171875	4.3655			27	.421875	10.7154			43	.671875	17.0653			59	.921875	23.4151	
6	12	.1875	4.7624	3/16	14	28	.4375	11.1122	7/16	22	44	.6875	17.4621	11/16	30	60	.9375	23.8120	15/16
	13	.203125	5.1592			29	.453125	11.5091			45	.703125	17.8590			61	.953125	24.2089	
7	14	.21875	5.5561		15	30	.46875	11.9060		23	46	.71875	18.2559		31	62	.96875	24.6057	
	15	.234375	5.9530			31	.484375	12.3029			47	.734375	18.6527			63	.984375	25.0026	
8	16	.25	6.3498	1/4	16	32	.5	12.6997	1/2	24	48	.75	19.0496	3/4	32	64	1.	25.3995	1

Fundamental Units

General Data

The electrical units are derived from the following mechanical units:

The centimeter, the unit of length.
The gramme, the unit of mass.
The second, the unit of time.

The centimeter equals .3937 of an inch, or one thousand-millionth part of a quadrant of the earth.

The gramme is equal to 15.432 grains, the mass of a cubic centimeter of water at 4° C.

The second is the time of one swing of the pendulum, making 86,464.09 swings per day, or the 1-86400 part of a mean solar day.

Mensuration

Circumference of circle whose diameter is $1 = \pi = 3.14159265$.
Circumference of any circle = diameter $\times \pi$.
Area of any circle = $(\text{radius})^2 \times \pi$, or $(\text{diameter})^2 \times 0.7854$.

Surface of sphere = $(\text{diameter})^2 \times \pi$, or = circumference $\times$ diameter.
Volume of sphere = $(\text{diameter})^3 \times 0.5236$, or = surface $\times \frac{1}{6}$ diameter.

Area of an ellipse = long diameter $\times$ short diameter $\times$ 0.7854.
$\pi^2 = 9.8696$; $\pi^{\frac{1}{2}} = 1.772454$; $\frac{\pi}{4} = 0.7854$.
$^1/\pi = 0.31831$; $\log \pi = 0.4971499$.
Basis of natural log $\varepsilon = 2.7183$; $\log \varepsilon = 0.43429$.
Modulus of natural logarithm $M = \dfrac{1}{\log \varepsilon} = 2.3026$.

$$1 \text{ lb. per sq. inch} = \begin{cases} 144 \text{ lb. per sq. foot.} \\ 51.7116 \text{ mm. of mercury.} \\ 2.30665 \text{ feet of water.} \\ 0.072 \text{ ton (short) per sq. foot.} \\ 0.0680415 \text{ atmosphere.} \end{cases}$$

One mile = 320 rods = 1760 yards = 5280 feet = 63,360 inches.
One fathom = 6 feet; 1 knot = 6080 feet.
1728 cubic inches = 1 cubic foot.
231 cubic inches = 1 liquid gallon = 0.134 cubic foot.
1 pound avoirdupois = 7000 grains = 453.6 grammes.
The angle of which the arc is equal to the radius, a Radian = 57.2958°.

Physical Data

The equivalent of one B.t.u. of heat = 778 foot-pounds.
The equivalent of one calorie of heat = 426 kg-m., = 3.968 B.t.u.
One cubic foot of water weighs 62.355 pounds at 62° F.
One cubic foot of air weighs 0.0807 pound at 32° F. and one atmosphere.
One cubic foot of hydrogen weighs 0.00557 pound.
One foot-pound = 1.3562×10^7 ergs.
One horse-power hour = $33{,}000 \times 60$ foot-pounds.

General Data

One horse-power = 33,000 foot-pounds per min. = 550 foot-pounds per second = 746 watts = 2545 B.t.u. per hour.

Acceleration of gravity (g) = 32.2 feet per second.
= 980 mm. per second.

One atmosphere = 14.7 pounds per square inch.
= 2116 pounds per square foot.
= 760 mm. of mercury.

Velocity of sound at 0° cent. in dry air = 332.4 metres per sec.
= 1091 feet per sec.

Velocity of light in vacuum = 299,853 km. per sec.
= 186,325 miles per sec.

Specific heat of air at constant pressure = 0.237.

A column of water 2.3 feet high corresponds to a pressure of 1 pound per square inch.

Coefficient of expansion of gases = $\frac{1}{273}$ = 0.00367.

Latent heat of water = 79.24.

Latent heat of steam = 535.9

Centigrade Degrees. To convert into the corresponding one in Fahrenheit degrees, multiply by $^9/_5$ and add 32. To convert it into the one in Réaumur degrees multiply by $^4/_5$. To convert it into the one on the Absolute scale, add 273.

Fahrenheit Degrees. To convert into the one in Centigrade degrees, subtract 32 and then multiply by $^5/_9$, being careful about the signs when the reading is below the melting point of ice. To convert it into the one in Réaumur degrees, subtract 32 and multiply by $^4/_9$. To convert it into the one on the Absolute scale, subtract 32, then multiply by $^5/_9$ and add 273; or multiply by 5, add 2297, and divide by 9.

Electrical Data

The ampere, I = unit of current = 0.1 cm.$^{1/2}$ g.$^{1/2}$ sec.^{1}.

The ohm = unit of resistance = 10.^{9} cm. sec.^{1}.

The volt, U = unit of e. m. f. = 10.^{8} cm.$^{\frac{3}{2}}$ g.$^{1/2}$ sec.^{2}

The henry, L = unit of inductance = 10.^{9} cm.^{1} sec.^{2}

The farad, C = unit of capacity = 10^6 cm.^{1}

$$\text{Watts}\begin{cases} = \text{unit of electric power} = \text{h. p.} \times 746. \\ = \text{current} \times \text{volts} \times \text{power factor.} \\ = \text{foot pounds per sec.} \div 1.355. \end{cases}$$

Joules, W = work done = watts × seconds.

$$1\text{ kw. hour} = \begin{cases} \text{3412 B. t. u.} \\ \text{2,654,536 foot-pounds.} \\ \text{3.53 pounds water evaporated at 212° F.} \\ \text{22.8 pounds water raised from 62° to 212° F.} \\ \text{0.235 pounds carbon oxidized at 100 per cent. eff.} \end{cases}$$

Bare Wires and Cables

Page

Copper

Trolley Wire 58
Wire and Cables 64–65
Hemp Core Cables 65
Extra Flexible Cables 66
Specifications for H. D. Copper Wire . . 66
Rail Bonds 67–70

Iron or Steel

Telephone and Telegraph Wires . . . 71–74
Specifications for galvanized Telephone and Telegraph Wires 72
Bond Wire, extra galvanized 74
Steel Signal Wire, extra galvanized . . . 75
Standard Steel Strand 75
Special Steel Strands 76
Galvanized Strand Clips 79
Resistance Wire 80
Armature Binding Wire 80
Armor Wire 81
Pole Steps 81
Silico-Magnetic-Core Steel 82

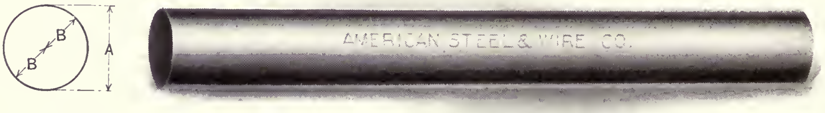
Bare Wires and Cables

Bare Conductors

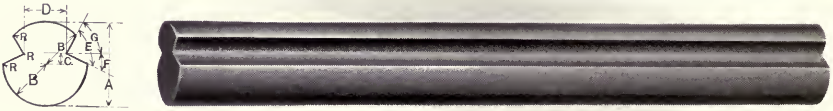
We make copper wire for all purposes in any required shape or size; copper cables of all capacities and degrees of flexibility; hard drawn or annealed, bare or insulated. We also make galvanized iron and steel wire in all shapes and sizes, bare or insulated, and for all purposes; telephone and telegraph wires, armor wires, strand and wire rope of all kinds.

Copper Trolley Wire

Since a trolley wire serves a double purpose, as conductor and as feeder to the moving current collector, it must be of high conductivity, and strong and durable. Copper can be readily drawn into any desired section and can be easily handled. Trolley wire is generally made of hard drawn copper in three shapes, round, grooved and figure 8. The latter form is not extensively used for two principal reasons. Owing to its unsymmetrical section, it is difficult to handle and to place in position. The non-uniformity in section, as made by different wire manufacturers, has rendered it impossible to make a uniform style of mechanical clamping ear for supporting the trolley. Though seldom called upon to make trolley wire larger than 4/0 or smaller than 1/0 B. & S. gauge, we are prepared to make other sizes. The various styles and sizes are shown dimensioned below:



Round



Grooved

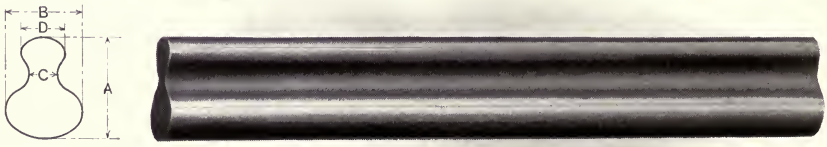


Figure 8

Bare Wires and Cables

Dimensions of Hard Drawn Copper Trolley Wire

Section of Trolley Wire	Size B. & S.	Sectional Area in Cir. Mils.	Approximate Dimensions (See Figure, Page 58)							
			A	B	C	D	E	F	G	R
Round	0	105,600	.325	.1625	..	..	..	..	..	..
	00	133,200	.365	.1825	..	..	..	..	..	..
	000	168,100	.410	.2045	..	..	..	..	..	..
	0000	211,600	.460	.230	..	..	..	..	..	..
Grooved "American Standard"	00	133,200	.392	.196	$\frac{1}{32}$	.20	78°	27°	51°	.015
	000	168,100	.430	.215	$\frac{3}{64}$	.22	78°	27°	51°	.015
	0000	211,600	.482	.241	$\frac{1}{16}$	.25	78°	27°	51°	.015
Figure 8	00	133,200	.480	.352	.108	.196	..	..	..	..
	000	168,100	.540	.400	.130	.222	..	..	..	..
	0000	211,600	.600	.450	.150	.250	..	..	..	..

Specifications for Hard Drawn Copper Trolley Wire

1. Conductivity, weight and strength.

Round, Grooved and Figure 8 Copper Trolley Wire

Size B. & S.	Approximate Weight, Pounds		Electrical Conductivity (Minimum)
	Per Mile	Per 1,000 Feet	
0	1685	319	Mile—ohm @ 68 degrees Fahr. not to exceed 890.1 equals 98% Matthiessen's Standard
00	2132	404	
000	2690	509	
0000	3386	641	

Round Trolley Wire

Size B. & S.	Tensile Strength, Pounds		Size B. & S.	Tensile Strength, Pounds	
	Actual	Per Square Inch		Actual	Per Square Inch
0	4522	54500	000	6735	51000
00	5550	52800	0000	8140	49000

The physical tests of all shapes shall be made in the same manner as those upon round wire. The tensile strength of grooved wire shall be at least 95 per cent. of that required for round wire of the same sectional area; the elongation shall be the same as that required for round wire of equal sectional area, given on page 67.

2. Sizes 1/0 and 2/0 approximately one mile on each reel; size 3/0 and 4/0 approximately one-half mile on each reel.

3. Round wire is to be cylindrical in form and of uniform size throughout. All forms to be uniform in quality, free from scale, flaws, splits and other defects inconsistent with the best commercial practice.

4. Round trolley wire may vary in diameter one per cent. either way. Shaped trolley wire may vary in diameter four per cent. over or under in weight per unit length from standard.

5. Wire to be shipped on firmly built reels suitable for proper handling and for the efficient protection of the wire in transit.

Base and Advances on Trolley Wire

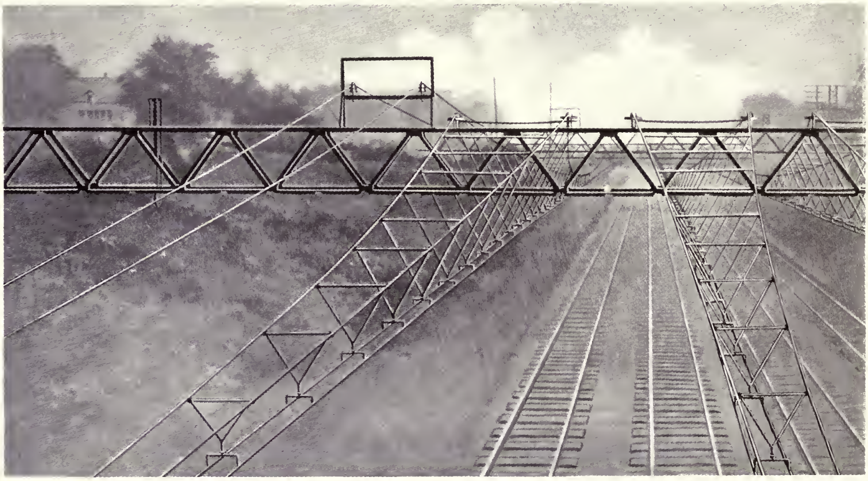
Round hard drawn copper	Base
Grooved and figure 8	¼ cent per pound advance over round

Bare Wires and Cables

Trolley Construction Notes

A mile of trolley wire strung in position is generally figured in calculations as 5350 feet, allowing 70 feet for sag and waste.

The trolley wire is usually suspended about 20 feet above the center of the track or to one side. It may be supported either from steel strands spanning the track between two side poles, from brackets extending out from the poles or from catenary construction. The trolley wire is supported by trolley "ears" which mechanically clamp the shaped wire, or which are soldered to the round wire. The trolley ears are attached to the supports by means of insulated trolley hangers.



Overhead Construction, N. Y., N. H. & H. R. R.

The following extracts from the specifications adopted by a leading railway company for overhead trolley construction are fairly representative of American electric railway practice.

Poles, Pole Framing and Pole Setting

Poles shall be of commercially straight, round chestnut, and shall conform to the dimensions shown in following table. Holes for the poles shall be excavated as here tabulated:

Round Pole Data

Length in Feet	Circumference Top in Inches	Depth in Earth in Feet	Circumference 5 Feet from Butt in Inches	Depth in Rock in Feet
30	22	6.0	36	5.0
35	22	6.0	38	5.5
40	22	6.5	44	5.5
45	22	6.5	47	6.0
50	22	7.0	50	6.5
55	22	7.5	53	6.5
60	22	8.0	56	7.0
65	22	8.5	58	7.0
70	22	9.0	58	7.0

Bare Wires and Cables

Poles are to be delivered barked and with knots trimmed.

They shall be sound and free from butt rot or hollows in butts which would impair strength above ground. They shall be free from unsound knots and shall have no more than one crook, this crook to be in one way only. Contractor shall point the tips, saw the butts off square, smooth all knots with draw knife, shave the entire pole, if so directed by the engineer, and paint the tips and gains of each pole with two coats of an approved metallic paint before installation.

Pole Setting

Poles shall be spaced 100 feet apart on tangents, and shall have a rake of 6 inches away from track at a height of 24 feet above top of track rail with bracket construction. With span construction the rake shall be 12 inches at same height above top of rail. Poles to have above rakes after taking final strain.

For longer poles and on side banks and fills, depths will be determined by inspecting engineer. Face of pole shall be spaced at a minimum distance of 5 feet from outside of rail head, and shall not exceed this measurement to appreciable extent unless conditions so require.

The earth around poles shall be thoroughly tamped with suitable tampers. When poles are set in concrete, the concrete shall consist of one part of an approved brand of Portland cement, three parts clean sharp sand and five parts broken stone, which will go through a 2-inch ring. Amount of concrete to be determined by inspecting engineer, and concrete to be put on in layers of 6 inches and each layer thoroughly tamped. Top of concrete filling to be above ground and sloped off from pole with smooth finish so as to shed water.

Curve Construction

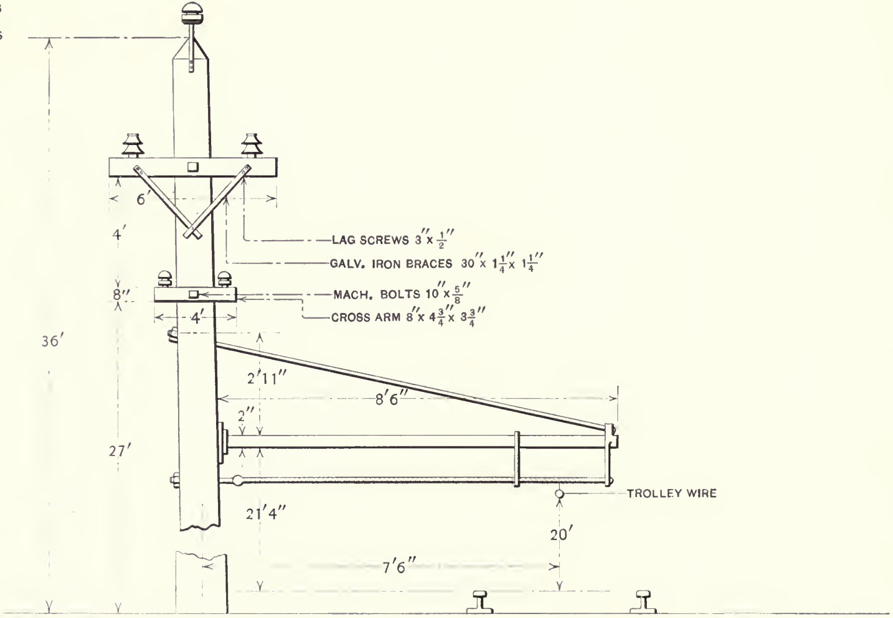
Pull-offs on curves shall be spaced according to following table:

Radius of Curve in Feet	Distance between Hangers in Feet	Radius of Curve in Feet	Distance between Hangers in Feet	Radius of Curve in Feet	Distance between Hangers in Feet	Radius of Curve in Feet	Distance between Hangers in Feet
40	5.0	85	7.0	400	20.0	900	40.0
50	5.5	100	7.5	550	25.0	1000	45.0
60	6.0	200	10.0	680	30.0	1500	60.0
75	6.5	300	15.0	800	35.0	1910	80.0

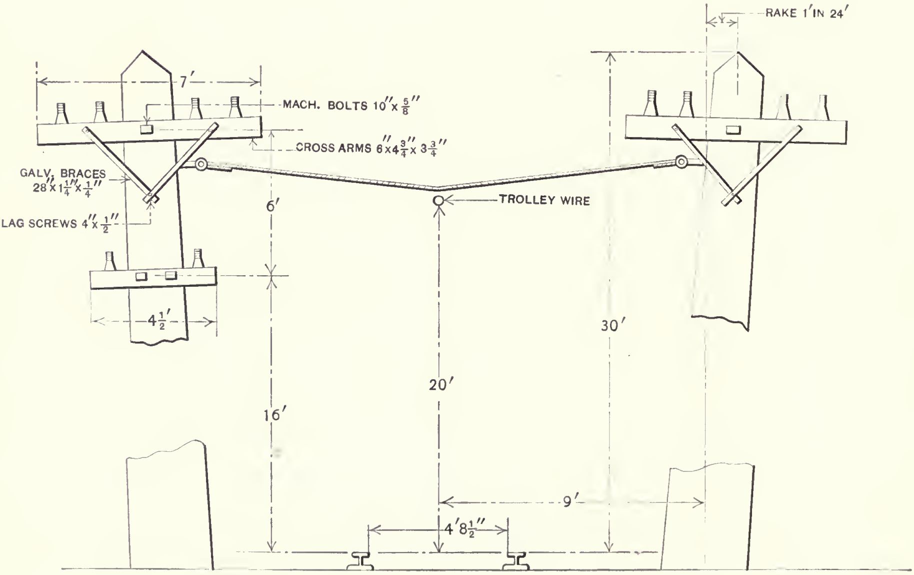
The distance between poles on curves is dependent on weight of feed wire, length of curve, and in towns, on local conditions. In general, the minimum distance between poles shall be 50 feet. Up to 1910 feet radius, space poles from 50 to 90 feet. Above 1910 feet radius, space poles 100 feet apart.

Span Construction

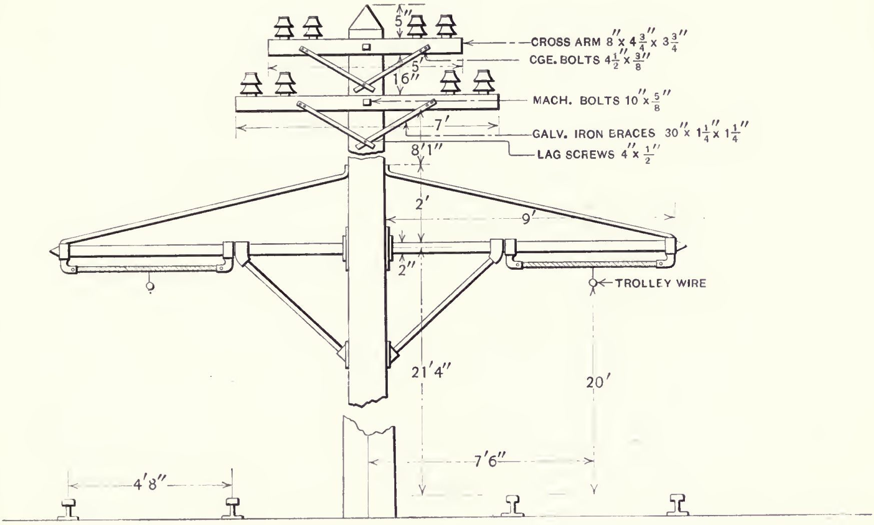
On single-track street railway lines use $\frac{5}{16}$-inch extra galvanized steel strand, tensile strength not less than 3300 pounds; on double-track street railway lines and on electrified steam lines, use $\frac{3}{8}$-inch extra galvanized steel strand, tensile strength not less than 4700 pounds, and use $\frac{3}{4}$-inch x 16-inch galvanized eye-bolts with thread cut 5 inches. All spans to be installed with eye-bolts at same level and allowance made for sag of 1 foot in 20 feet of span, with eye-bolts at full length.


6′
4′
LAG SCREWS 3″x $\frac{1}{2}$″
GALV. IRON BRACES 30″x $1\frac{1}{4}$″x $1\frac{1}{4}$″
8″
MACH. BOLTS 10″x $\frac{5}{8}$″
4′
CROSS ARM 8″x $4\frac{3}{4}$″x $3\frac{3}{4}$″
36′
2′11″
8′6″
2″
27′
TROLLEY WIRE
21′4″
20′
7′6″

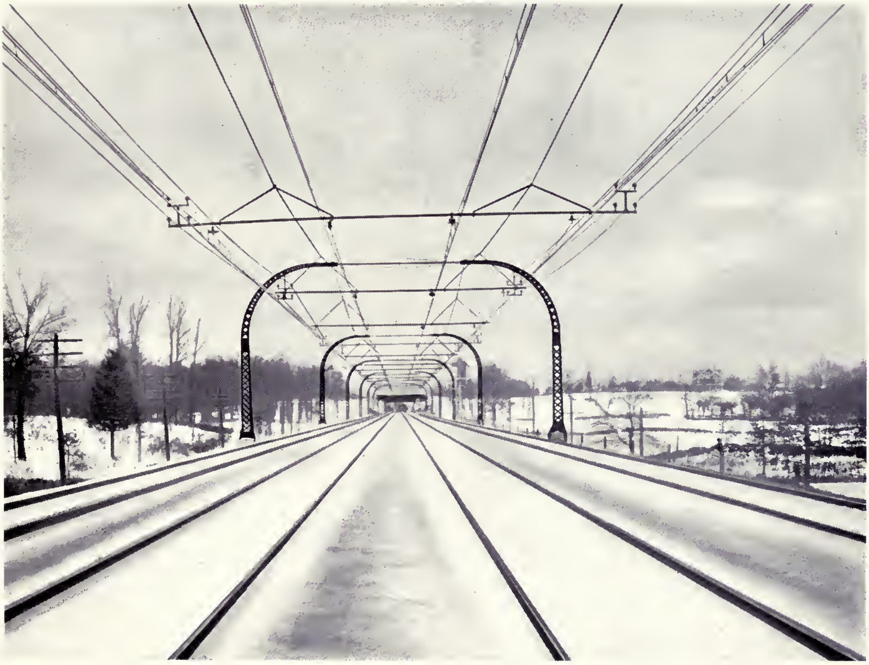
Side Pole Bracket Construction


RAKE 1′IN 24′
7′
MACH. BOLTS 10″x $\frac{5}{8}$″
CROSS ARMS 6″x$4\frac{3}{4}$″x $3\frac{3}{4}$″
GALV. BRACES 28″x$1\frac{1}{4}$″x$\frac{1}{4}$″
LAG SCREWS 4″x $\frac{1}{2}$″
6′
TROLLEY WIRE
4$\frac{1}{2}$′
30′
20′
16′
9′
4′8$\frac{1}{2}$″

Span Construction


5″
CROSS ARM 8″ x 4¾″ x 3¾″
CGE. BOLTS 4½″ x ⅜″
5′
16″
MACH. BOLTS 10″ x ⅝″
7′
GALV. IRON BRACES 30″ x 1¼″ x 1¼″
8′1″
LAG SCREWS 4″ x ½″
2′
9′
2″
TROLLEY WIRE
21′4″
20′
7′6″
4′8″

Center Pole Construction



Recent Catenary Construction on N. Y., N. H. & H. R. R., near Glenbrook, Conn.

Bare Wires and Cables

Bare Copper Wire and Cables

Made in all sizes, hard drawn or annealed, and for all purposes. For telephone and telegraph, high voltage long distance transmission, and industrial purposes in general. Full information concerning the properties of bare copper wire with tabulated data is given in the foregoing section, pages 14 and 25.

Bare Copper Wire Advances

Advances per pound over and above base prices for annealed and hard drawn copper wire:

B. & S. Gauge Number	Advance per Pound Cents
0000 to 8	Base
9 and 10	Add ⅛
11 and 12	Add ¼
13 and 14	Add ½
15 and 16	Add ¾
17 and 18	Add 1
19 and 20	Add 1¼
21 and 22	Add 1⅝
23 and 24	Add 2½

For wire finer than 24 B. & S. gauge, special prices on application.

Orders for copper wire will be filled by standard B. & S. gauge unless otherwise specified.

Tinned Copper Wire Advances

Advances per pound over and above prices for corresponding sizes of annealed bare copper wire.

B. & S. Gauge Number	Advance per Pound Cents	B. & S. Gauge Number	Advance per Pound Cents
0000 to 8	¾	18 and 19	1¼
9 and 10	¾	20	1½
11 and 12	¾	21	1¾
13 and 14	1	22	2
15 and 16	1	23	2½
17	1	24	3

Hard Drawn Copper Telegraph and Telephone Wire

Size B. & S. Gauge			British Imperial, or English Legal Standard Gauge		
Number	Diameter in Decimal of an Inch	Approximate Weight per Mile in Pounds	Number	Diameter in Decimal of an Inch	Approximate Weight per Mile in Pounds
8	.1285	264	8	.160	409
9	.1144	209	9	.144	331
10	.1019	166	10	.128	262
12	.0808	104	12	.104	173
14	.0641	66	14	.080	102

Bare Wires and Cables

Cutting to Lengths

For lengths less than 20 feet, add a minimum of ½ cent per pound to the schedule; 20 feet or over, add ¼ cent per pound. For very short lengths of fine wire, such as tag wire, the price increases rapidly as the length decreases.

Reels

Will be charged at prices quoted on page 50. When returned in good condition, with slats, within six months from date of shipment, freight prepaid to the factory, customers will receive credit for the full amount originally charged.

Bare Copper Cables, Annealed and Cleaned, or Hard Drawn

These extras apply both on concentric and rope laid conductors. See pages 29 and 34 for wiring tables, giving complete information about copper cables.

To determine the price of any bare stranded cable, add to the price for the wire of which the strand is composed the extras as given below.

When the following sizes of wire, B. & S. gauge, are used:

Number	Advance per Pound Cents	Number	Advance per Pound Cents
8 or coarser	½	17 to 20 inclusive	2
9 to 13 inclusive	¾	21 to 24 inclusive	5
14 to 16 inclusive	1¼	25 and smaller	Prices on request

Intermediate sizes of wire take extra applying to next smaller gauge.

For example, in determining prices of cables

500,000 circular mils, 61 wires concentric strand.

Each wire has 8196 circular mils and is approximately 12 B. & S. gauge.

Price bare wire, base size	$15.00 per 100 pounds
Advance for size (12 B. & S. gauge) .	.25, see page 64
Advance for stranding	.75, see above
Freight	

Hemp Core Cables

In order to reduce the skin effect in conductors carrying heavy alternating currents of high frequency, it is customary to use a specially constructed cable having a hemp center. This style of cable is also required in many long distance transmission lines in order to increase the diameter enough to prevent corona effects due to very high potentials.

We are prepared to manufacture this style of cable to any specifications.

AMERICAN STEEL & WIRE CO.

Bare Wires and Cables

Extra Flexible Cables

We manufacture bare copper cables having a high degree of flexibility due to their being made up of a large number of small wires. These cables are for flexible connectors, for commutator brushes, third rail shoes and similar purposes. They are made both concentric and rope lay and price is figured from same schedule of advances.

Specifications for Hard Drawn Copper Wire

1. The material shall be copper of such quality and purity that when drawn hard it shall have the properties and characteristics herein required.

2. These specifications cover hard drawn round wire and hard drawn cable or strand as hereinafter described.

3. The wire in all shapes must be free from all surface imperfections not consistent with the best commercial practice.

4. (*a*) Package sizes for round wire and for cable shall be agreed upon in the placing of individual orders.

(*b*) The wire shall be protected against damage in ordinary handling and shipping.

5. For the purpose of calculating weights, cross-sections, etc., the specific gravity of copper shall be taken as 8.90.

6. All testing and inspecting shall be made at the place of manufacture, and when the wire is found to meet specifications it shall then and there be accepted by purchaser. The manufacturer shall afford the inspector representing the purchaser all reasonable facilities to enable him to satisfy himself that the material conforms to the requirements of these specifications.

Hard Drawn Round Wire

7. (*a*) Sizes shall be expressed as the diameter of the wire either in decimals of an inch or in mils, or in the B. & S. gauge.

(*b*) Permissible variations from actual gauge diameter shall be as shown in the table, page 24.

8. The wire shall be so drawn that its tensile strength and elongation shall be at least equal to the value stated in the following table. Tensile tests shall be made upon fair samples and the elongation shall be determined as the permanent increase in length, due to the breaking of the wire in tension, measured between bench marks placed upon the wire originally 10 inches apart. The fracture shall be between the bench marks and not closer than 1 inch to either mark. If upon testing a sample from any coil of wire, the results are found to be below the values stated in the table, tests upon two additional samples shall be made, and the average of the three tests shall determine acceptance or rejection of the coil.

Properties of Hard Drawn Copper Wire

(Adopted by the A. S. T. M.)

Size B. & S.	Diameter Inches	Area Circular Mils	Tensile Strength Pounds per Sq. Inch	Per Cent. Elongation in 10 Inches	Size B. & S.	Diameter Inches	Area Circular Mils	Tensile Strength Pounds per Sp. Inch	Per Cent. Elongation in 10 Inches
0000	0.460	211,600	49,000	3.75	8	0.128	16,380	63,400	1.4
000	0.410	168,100	51,000	3.20	9	0.114	12,996	64,200	1.3
00	0.365	133,200	52,800	2.70	10	0.102	10,404	64,800	1.2
0	0.325	105,600	54,500	2.4	11	0.091	8,281	65,400	1.1
1	0.289	83,520	56,000	2.1	12	0.081	6,561	65,700	1.0
2	0.258	66,560	57,500	2.0	13	0.072	5,184	66,000	0.9
3	0.229	52,440	58,500	1.9	14	0.064	4,096	66,200	0.9
4	0.204	41,620	59,500	1.8	15	0.057	3,249	66,400	0.8
5	0.182	33,120	60,500	1.7	16	0.051	2,601	66,600	0.8
6	0.162	26,240	61,500	1.6	17	0.045	2,025	66,800	0.7
7	0.144	20,740	62,500	1.5	18	0.040	1,600	67,000	0.7

For wire whose nominal diameter is between listed sizes, the requirements shall be determined by interpolation from those included in the table.

9. Electrical conductivity shall be determined upon fair samples by resistance measurements at a temperature of 20° C. (68° F.). The wire shall not exceed the following limits:

For diameters 0.460 to 0.325 inch, 890.1 pounds per mile-ohm at 20° C., equal to 98 per cent. Matthiessen's standard.

For diameters 0.324 to 0.102 inch, 899.3 pounds per mile-ohm at 20° C., equal to 97.0 per cent. Matthiessen's standard.

For diameters 0.101 to 0.040 inch, 908.7 pounds per mile-ohm at 20° C., equal to 96.0 per cent. Matthiesson's standard.

Hard Drawn Copper Wire Strand

10. For the purpose of these specifications, standard strand shall be that made up of hard drawn wire laid concentrically about a hard drawn wire center. Cable laid up about a hemp center or about a soft wire core is to be subject to special specifications to be agreed upon in individual cases.

11. The wire entering into the construction of strand shall, before stranding, meet all the requirements of round wire hereinbefore stated.

12. The tensile strength of standard strand shall be at least 90 per cent. of the total strength required of the wires forming the strand.

13. Brazes, made in accordance with the best commercial practice, will be permitted in wire entering into strand. The brazed joint shall have at least 95 per cent. of the strength specified for the wire.

14. The lay of standard strand shall not be less than 12, nor more than 16 diameters of the strand.

Rail Bonds

The subject of rail bonds is properly included with that of other bare electrical conductors. We are exceptionally well equipped to make rail bonds of any desired type, capacity or length to meet any requirements. We manufacture all standard types of terminal stud bonds from which any particular style of

Bare Wires and Cables

bond can be selected that will best serve for any given set of track conditions. Our bonds are distinguished by accurate workmanship, superior grade of material and simplicity of design, qualities which will insure lasting and economical service.

We make four styles of rail bonds: *Crown* rail bonds, with round wire conductors; *United States* rail bonds, with flat wire conductors; *Twin Terminal* bonds to be attached to the heads of rails, and *Soldered* rail bonds. Only pure annealed copper of high conductivity is used in any portion of these bonds. The solid terminals, after being forged to shape from rolled copper rods, are heated and drop forged to the flexible conductor portion, producing a union having all the merits of homogeneous copper.

There are two styles of stud terminals shown on the Crown and on the United States bonds. One is a tubular terminal, and is applied by driving a long taper punch through the hollow terminal, distending it radially, after which a short drift pin is driven into the terminal, expanding it $\frac{1}{32}$-inch more. The other style of terminal has a solid stud and is installed with a compressor. When correctly installed, either style will give equally good results. The stud portion of all terminals is milled smooth and accurate to size, thus insuring a most efficient and lasting contact.

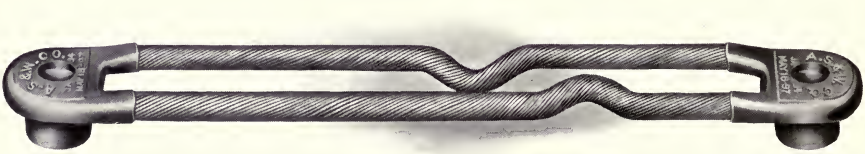
The Twin Terminal bond is applied by hammer compression. This makes an ideal bond in all respects for exposed T-rail joints.

We make two styles of *Rail Bond Testers*, each having special merits. The A. S. & W. tester is suitable for very accurate measurements. The *Crown* is very easily handled, less expensive and is used to indicate the presence of poor bonding.

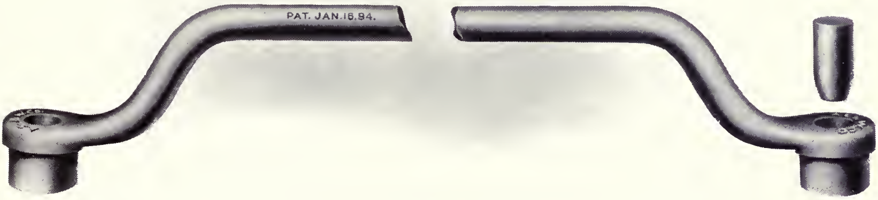
The durability and efficiency of a bond installation will depend largely upon the effectiveness of the *tools* used. Even the best workmen cannot do good work with poor bonding tools. In developing our bonding tools no expense has been spared nor time considered. First and foremost, the aim has been to produce tools of the greatest effectiveness and perfect suitability for the service to which they were to be put ; to make them as perfect in every detail as possible, and to make them light, durable and reasonable in cost.

A new and revised rail bond catalogue describing our complete bonding equipment will be sent on request.

Correspondence is solicited, and data and estimates will gladly be furnished. Only a few of the bonds and tools which we make are shown below and on next page.



Crown Rail Bond, Type C P-03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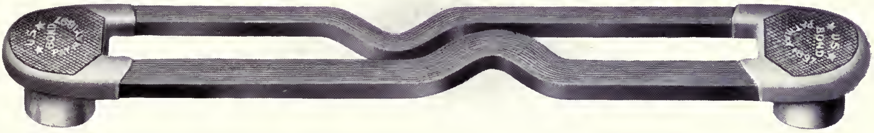
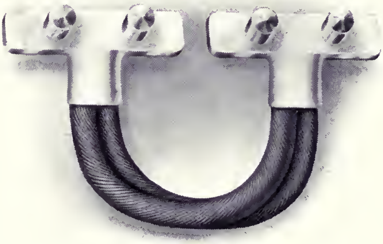
Crown Rail Bond, Type C P S

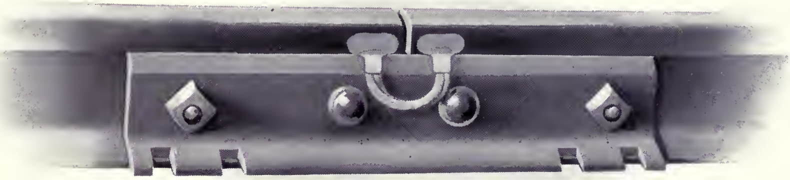

U.S. ★ BOND ★ PAT'D

United States Rail Bond, Type U S 1

Twin Terminal Rail Bond, Form B



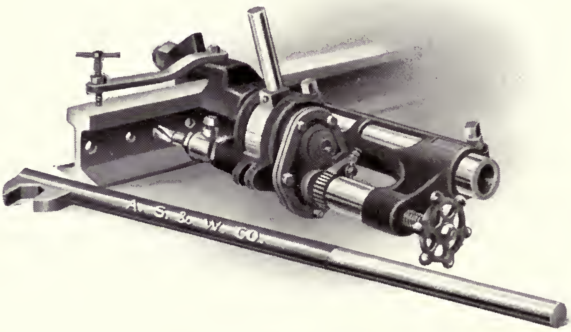
Soldered Stud Rail Bond



Twin Terminal Bond Applied

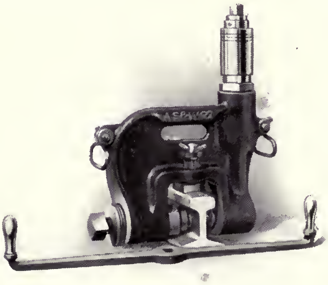
Bonding Tools

We make and constantly keep in stock, special high grade tools for the correct installation of each type of rail bond. For ease of handling and adjusting, rapidity of action and general effectiveness, these bonding tools have no equal. We also contract for the complete installation of any type of bond manufactured by us.

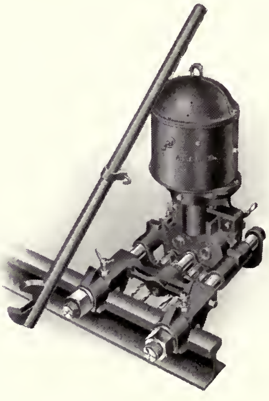


Single Spindle Drill, No. 21

This drill should always be used in connection with our Crown and United States bonds. The machine grips the rail head rigidly and is fed automatically. In consequence the hole is true to size and has a smooth wall. It is light and durable, easily operated by one man and is driven forward by each stroke of the lever.



No. 61. Screw Hydraulic Compressor
(Patented)



Four-Spindle Motor Drill
Used with Installation of Twin Terminal and Soldered Stud Bonds
(Patented)

Bare Wires and Cables

Extra Galvanized W. & M. Telephone and Telegraph Wire

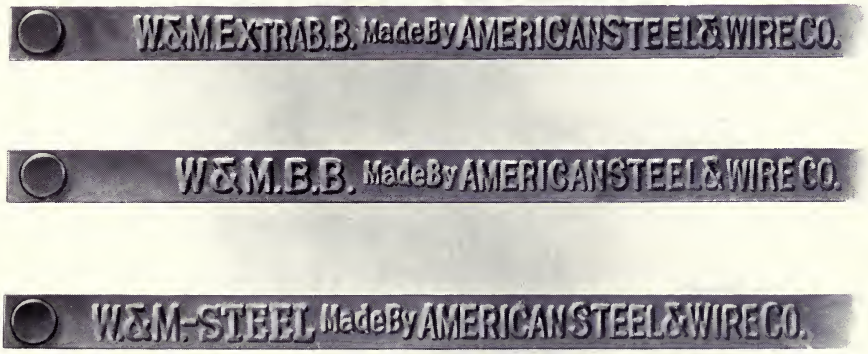
There are three standards of extra galvanized telephone and telegraph wire in general commercial use:

"Extra Best Best" (E.B.B.). Made by improved continuous process and stands highest in conductivity of any telegraph wire with a weight per mile ohm of from 4700 to 5000 pounds. Uniform in quality, pure, tough and pliable. It is largely used by telegraph companies and in railway telegraph service.

"Best Best" (B.B.). Superior to the E.B.B. in mechanical qualities and equal in galvanizing, but of somewhat lower electrical value. Weight per mile ohm, 5600 to 6000 pounds. This grade is used very largely by telephone companies.

"Steel" (or homogeneous metal). More expressly designed for short-line telephone service, where a measure of conductivity can be exchanged for high tensile strength in a light wire. Weight per mile-ohm, 6500 to 7000 pounds.

Around each bundle is securely riveted a metal seal stamped W. & M. E. B. B., W. & M. B. B., or W. & M. Steel, as follows:


W.&M.EXTRA B.B. Made By AMERICAN STEEL & WIRE CO.
W.&M.B.B. Made By AMERICAN STEEL & WIRE CO.
W.&M.-STEEL Made By AMERICAN STEEL & WIRE CO.

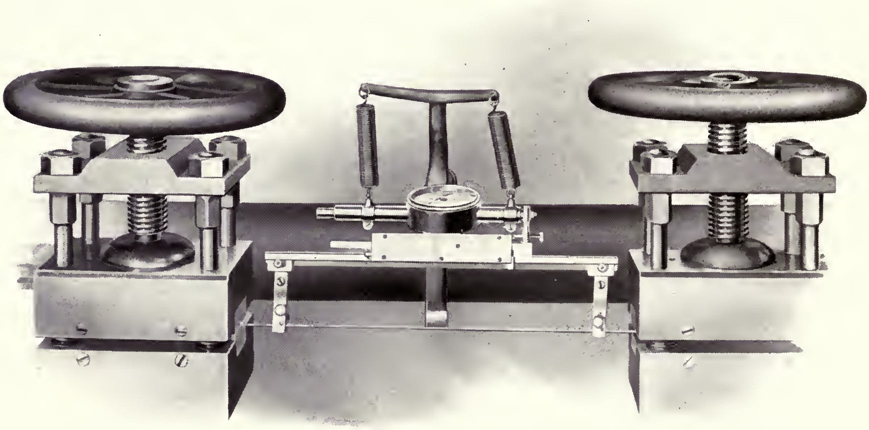
Seals for Telephone and Telegraph Coils of Wire

The arbitrary designation of these different qualities, as E. B. B., B. B., and Steel, was adopted several years ago. The three grades are all made from the very best materials by improved processes under the careful supervision of skilled and experienced men.

Bare Wires and Cables

While these three grades differ in physical characteristics, there is no difference in the standard as regards galvanizing. All grades are galvanized to the highest commercial standard—a standard which is the result of more than half a century's experience.

A complete description of the processes involved in the manufacture of W. & M. Iron and Steel Telephone and Telegraph Wire is given on pages 39 to 44. Every bundle of wire before shipment is tested physically and electrically to insure a uniform product of high standard and the galvanizing is tested to determine that the zinc coating is continuous, is elastic and of sufficient thickness and fully up to the highest commercial standard. The latter test is a chemical, not merely a visual, one. The life of a galvanized wire depends primarily upon the thickness and grade of galvanizing and not upon the color of the galvanizing. No greater mistake could be made than to buy telephone wire on what is properly termed "looks." Under the corroding influences of smoke and air, the "looks" of the wire soon fade and something other than this is required in order that efficient and economical service and long life be rendered.



Machine for Testing Telegraph Wire

Specifications for Galvanized Telephone and Telegraph Wire

Testing Facilities. The manufacturer shall provide suitable facilities for making the tests hereinafter specified.

Finish. The wire shall be cylindrical in form and free from scales, inequalities, flaws, splints and other imperfections.

The finish of the wire shall be in accordance with the best commercial practice.

Each coil shall be warranted not to contain any weld, joint or splice in the rod before drawn.

Galvanizing. The wire shall be well galvanized in accordance with the following specifications:

> The galvanizing shall consist of a continuous coating of pure zinc of practically uniform thickness, and so applied that it adheres firmly to the surface of the wire. No. 12 B. W. G. and coarser sizes of wire shall be capable of withstanding the following test:
>
> TESTING SOLUTION. A standard solution shall be prepared by selecting from commercial sulphate of copper crystals, those which are clean and

Bare Wires and Cables

have a clear blue color, and dissolving them in lukewarm water. The solution shall be allowed to stand for at least twelve hours with occasional stirring. Some undissolved crystals should remain at the bottom of the vessel at the end of this time. The solution shall be neutralized by the addition of an excess of cupric oxide. The neutralized solution shall then be filtered before using. (See note below.)

METHOD OF TESTING. Samples of wire previously cleaned with gasoline or benzine shall be immersed, to a distance of at least four inches, in a glass vessel containing not less than one pint of the standard solution and allowed to remain for one minute. They shall then be removed, washed in clear water and wiped dry with soft cotton cloth or waste. This process shall be repeated three times, making four immersions in all.

Note. A saturated solution of sulphate of copper thus prepared should have a specific gravity of 1.186 at a temperature of 65 degrees F. In case of No. 14 B. W. G. wire, the fourth immersion shall be of one-half minute duration instead of one minute.

The temperature of the solution during the test shall not be above 68 degrees F. or below 62 degrees F.

Not more than seven samples of wire shall be immersed at one time, and no solution shall be used for more than one set of four immersions.

If a bright copper deposit appears on the steel after the fourth immersion, thus indicating that the wire is exposed, the galvanizing of the lot of wire represented by the samples shall be considered faulty. Copper deposits on zinc or within one inch of the cut end shall not be considered causes for rejection.

Physical and Electrical Requirements. The galvanized wire shall conform to the following physical requirements with respect to resistances, weights and breaking strains.

Torsion. The wire shall be capable of withstanding at least fifteen (15) twists in a length of six (6) inches.

In the case of wire less than 0.134 inch in diameter one-third (⅓) of the coils may have two (2) pieces to a coil joined by the ordinary twist joint carefully soldered and galvanized.

In the case of wire 0.134 inch in diameter and larger, each coil may consist of two pieces only joined by the ordinary twist joint carefully soldered and galvanized.

Binding. Each coil of wire shall be securely bound in at least four places with galvanized iron wire. A tag shall be attached to each coil, giving the size and grade of wire in the coil.

Properties of Galvanized Telephone and Telegraph Wires

Based on Standard Specifications

Size B. W. G	Diameter in Mils=d	Area in Circular Mils=d^2	Approximate Weight in Pounds		Approximate Breaking Strain in Pounds			Resistance per Mile (International Ohms) at 68° F. or 20° C.		
			Per 1000 Feet	Per Mile	Ex. B. B.	B. B.	Steel	Ex. B. B.	B. B.	Steel
0	340	115,600	313	1,655	4,138	4,634	4,965	2.84	3.38	3.93
1	300	90,000	244	1,289	3,223	3,609	3,867	3.65	4.34	5.04
2	284	80,656	218	1,155	2,888	3,234	3,465	4.07	4.85	5.63
3	259	67,081	182	960	2,400	2,688	2,880	4.90	5.83	6.77
4	238	56,644	153	811	2,028	2,271	2,433	5.80	6.91	8.01
5	220	48,400	131	693	1,732	1,940	2,079	6.78	8.08	9.38
6	203	41,209	112	590	1,475	1,652	1,770	7.97	9.49	11.02
7	180	32,400	87	463	1,158	1,296	1,389	10.15	12.10	14.04
8	165	27,225	74	390	975	1,092	1,170	12.05	14.36	16.71
9	148	21,904	60	314	785	879	942	14.97	17.84	20.70
10	134	17,956	49	258	645	722	774	18.22	21.71	25.29
11	120	14,400	39	206	515	577	618	22.82	27.19	31.55
12	109	11,881	32	170	425	476	510	27.65	32.94	38.23
13	95	9,025	25	129	310	347	372	37.90	45.16	52.41
14	83	6,889	19	99	247	277	297	47.48	56.56	65.66
15	72	5,184	14	74	185	207	222	63.52	75.68	87.84
16	65	4,225	11	61	152	171	183	77.05	91.80	106.55

W. & M. Telephone Wire—Continued

Prices quoted on application

Sizes Birmingham Wire Gauge	Diameter in Decimals of an Inch	Bdls. per Mile	Weight per 1000 Feet in Pounds	Weight per Mile in Pounds	Sizes Birmingham Wire Gauge	Diameter in Decimals of an Inch	Bdls. per Mile	Weight per 1000 Feet in Pounds	Weight per Mile in Pounds
4	0.238	4	153	811	10	0.134	2	49	258
6	0.203	3	112	590	11	0.120	2	39	206
8	0.165	2	74	390	12	0.109	2	32	170
9	0.148	2	60	314	14	0.083	2	19	99

Data Concerning Telephone and Telegraph Poles

Length of Pole, Feet	Diameter Six Inches from Butt Inches	Diameter at Top Inches	Depth Pole Should be Placed in Ground, Feet	Length of Pole, Feet	Diameter Six Inches from Butt Inches	Diameter at Top Inches	Depth Pole Should be Placed in Ground, Feet
25	9 to 10	6 to 8	5	55	16 to 17	6 to 8	7½
30	9 to 11	6 to 8	5½	60	16 to 18	6 to 8	7½
35	9 to 12	6 to 8	5½	65	16 to 19	6 to 8	8
40	9 to 13	6 to 8	6	70	16 to 20	6 to 8	8
45	9 to 14	6 to 8	6½	75	16 to 21	6 to 8	8½
50	9 to 15	6 to 8	7	80	16 to 22	6 to 8	9

Sizes and Weights of White Cedar Poles

(Northwestern Cedarmen's Association specifications)

Description

Length Feet	Top Diameter Inches	Weight Pounds	Length Feet	Top Diameter Inches	Weight Pounds	Length Feet	Top Diameter Inches	Weight Pounds
20	4	100	35	6	450	55	6	1,350
20	5	130	35	7	600	55	7	1,700
20	6	190	35	8	850	55	8	2,200
25	4	150	40	6	625	60	6	1,700
25	5	200	40	7	850	60	7	2,200
25	6	250	40	8	1,100	60	8	2,500
25	7	350	45	6	900	65	6	2,200
30	5	275	45	7	1,100	65	7	2,500
30	6	350	45	8	1,350	65	8	3,000
30	7	450	50	6	1,150	70	6	2,500
30	8	575	50	7	1,350	70	7	3,000
35	5	375	50	8	1,700	70	8	4,000

Extra Galvanized Bond Wire

Used for signal bonding on steam roads. Extra B. B. extra galvanized telephone wire is nearly always used for this purpose. Cut and straightened to lengths at a small extra charge. Usually 3 to 5 feet long, and of any gauge number desired.

Extra Galvanized Steel Signal Wire

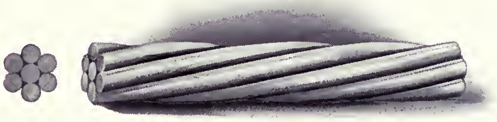
This wire is used as a connection from a lever or other pulling device to a semaphore signal which is operated mechanically. The two sizes of Extra Galvanized Signal Wire in common use are:

No. 8 B. W. gauge, with an approximate breaking strength of 2350 pounds.
No. 9 B. W. gauge, with an approximate breaking strength of 1900 pounds.

The wire is made especially to meet the important requirements of this service. It is extra galvanized, and of a quality that possesses high strength and as low elongation as is practicable without sacrificing toughness. The coils are 5 feet in diameter, and approximately one-half mile in length without welds or joints.

Steel Strand for Guying Poles and for Span Wire

Galvanized or Extra Galvanized



Seven Steel Wires Twisted into a Single Strand

Standard Steel Strand

Galvanized or Extra Galvanized

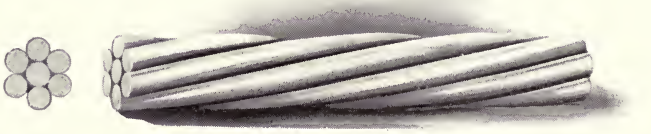
Diameter in Inches	Approximate Weight per 1000 Feet Pounds	Approximate Strength in Pounds	List Prices per 100 Feet	Diameter in Inches	Approximate Weight per 1000 Feet Pounds	Approximate Strength in Pounds	List Prices per 100 Feet
½	510	8500.	$4.50	7/32	95	1800.	$1.50
7/16	415	6500.	3.75	3/16	75	1400.	1.25
⅜	295	5000.	2.75	5/32	55	900.	1.15
5/16	210	3800.	2.25	⅛	32	500.	1.00
¼	125	2300.	1.75	3/32	20	400.	.80

This strand is used chiefly for guying poles and smoke stacks, for supporting trolley wire, and for operating railroad signals.

For overhead catenary construction suspending trolley wire, the special grades of strand are considered preferable because they possess greater strength and toughness.

Bare Wires
and Cables

Extra Galvanized Special Strands



Seven Steel Wires Twisted into a Single Strand

We manufacture three special grades of Extra Galvanized Strand which will meet all requirements for durability, strength, toughness and light weight.

Extra Galvanized Siemens-Martin Strand.

Extra Galvanized High Strength (crucible steel) Strand.

Extra Galvanized Extra High Strength (plow steel) Strand.

Strands of all three grades are composed of seven wires each, and they have a very heavy coating of galvanizing, which insures long life.

Extra Galvanized Siemens-Martin Strand					Extra Galvanized High Strength Strand					Extra Galvanized Extra High Strength Strand				
Diameter in Inches	Actual Breaking Strength in Pounds	List Prices per 100 Feet	Elastic Limit Per Cent.	Per Cent. Elongation in 24 Inches	Diameter in Inches	Actual Breaking Strength in Pounds	List Prices per 100 Feet	Elastic Limit Per Cent.	Per Cent. Elongation in 24 Inches	Diameter in Inches	Actual Breaking Strength in Pounds	List Prices per 100 Feet	Elastic Limit Per Cent.	Per Cent. Elongation in 24 Inches
⅝	19,000	$4.35	50	10.0	⅝	25,000	$6.25	55	6	⅝	42,500	$8.75	60	4
½	11,000	2.80	50	10.0	½	18,000	3.95	55	6	½	27,000	5.50	60	4
7/16	9,000	2.30	50	10.0	7/16	15,000	3.45	55	6	7/16	22,500	4.60	60	4
⅜	6,800	1.80	50	10.0	⅜	11,500	2.70	55	6	⅜	17,250	3.55	60	4
5/16	4.860	1.35	50	10.0	5/16	8,100	2.10	55	6	5/16	12,100	2.70	60	4
9/32	4,380	1.10	50	10.0	9/32	7,300	1.75	55	6	9/32	10,900	2.10	60	4
¼	3,060	1.00	50	10.0	¼	5,100	1.50	55	6	¼	7,600	1.90	60	4
3/16	2,000	.85	50	10.0	3/16	3,300	1.30	55	6	3/16	4,900	1.60	60	4
⅛	900	.55	50	10.0	⅛	1,500	.80	55	6	⅛	2,250	1.05	60	4
Special 5/16	6,000	1.35												

When intermediate sizes or strengths are called for, if they are exactly midway between two sizes provided for, the average price of the two sizes shall apply, otherwise the price of the nearest size and strength shall apply.

The use of these special grades of Extra Galvanized Strand is constantly increasing. We will consider briefly some of the principal uses to which they are particularly adapted.

Messenger Strand. The heavy encased telephone cables are not in themselves sufficiently strong, without an unusual deflection, to safely withstand the strain incident to stringing these cables between poles at considerable distances apart. It is common practice now to stretch from pole to pole, with very little sag, 5/16-inch diameter Extra Galvanized Siemens-Martin Strand; or Extra Galvanized High Strength Strand of ⅜ inch or 7/16 inch diameter, and from this messenger strand the heavy telephone cable is suspended by means of clips, wire, cord, or marline at short intervals. The messenger strand thus sustains most of the stress due to weight of cable, wind or ice load. We have mentioned the sizes and qualities now generally employed by the largest telephone companies. The Extra Galvanized Extra High Strength Strand, while affording the greatest strength for its weight, is naturally stiff and springy and not so easy to fasten. The so-called common galvanized strand should never be used for messenger lines, as it does not possess the requisite strength and uniform toughness of the special grades of steel.

Catenary Method of Supporting Trolley Wire. In the ordinary electric railway overhead construction, the copper trolley wire dips and sags between the supporting points, which are opposite poles, and from 100 to 125 feet apart. The catenary method of carrying the trolley wire consists of one or more messenger strands stretched over the center of the tracks. Every few feet along the messenger strand are pendant hangers that clamp on the trolley wire and retain it in a rigid, straight horizontal line, an especially desirable feature for the operation of electric cars at high speed. The catenary construction also makes it possible to space the poles at greater distances apart, but this necessarily causes great tension on the messenger strand and poles. The common galvanized strand is not suitable for this work. The selection of the best size and quality of strand depends upon the length of span, the deflection of the messenger strand, and the weight of the trolley wire. In general, however, for a single messenger strand carrying a 4/0 copper trolley wire, we would recommend the following :

For spans 125 to 150 feet, ⅜-inch or $\frac{7}{16}$-inch diameter Extra Galvanized Siemens-Martin Strand.

For longer spans up to 225 feet, ⅜-inch or $\frac{7}{16}$-inch Extra Galvanized High Strength Strand.

These two grades have been found the best for catenary work.

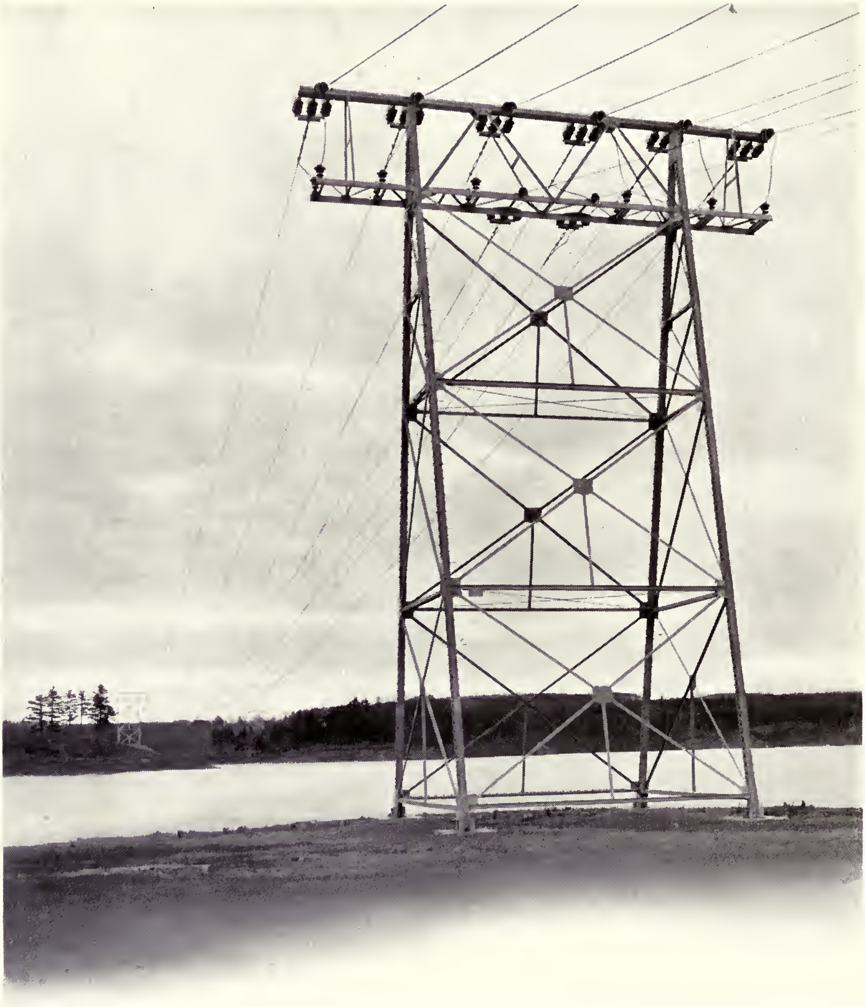
The messenger strand and trolley wire may be made to follow track curves by increasing the number of poles at the curves, but this is obviated by attaching to the hangers near the center of span what are known as "pull-off" strands. Our ¼-inch or $\frac{5}{16}$-inch diameter Extra Galvanized Siemens-Martin Strand is usually employed for this purpose.

For reasons already explained, the poles should be well guyed, especially at the curves, with ¼-inch or $\frac{5}{16}$-inch diameter Extra Galvanized Siemens-Martin Strand.

Lightning Protection for Transmission Lines. In erecting high-tension current transmission lines on tall steel towers, it is customary to stretch between the highest points of the towers a ⅜-inch diameter Extra Galvanized Siemens-Martin Strand, known as an "overhead ground wire." This strand is employed almost invariably for such purposes.

Long Spans in High-tension Current Transmission Line. Long spans cannot always be made with copper cables, because hard drawn copper has a strength of only 65,000 pounds per square inch. Where it is necessary to cross over rivers, lakes and bays with power transmission lines, the current may be conducted through an extra galvanized strand of one of the three special grades of steel above described, of such size and strength as will show a safety factor of at least five. It is not necessary to suspend bare copper cables beneath a steel messenger strand, as the steel strand itself will serve as the conductor. An entire power transmission line of very high potential could be economically constructed with Extra Galvanized Siemens-Martin Strand, the adoption of which in place of copper cable would reduce the number of supporting towers which are often the cause of energy loss and trouble.

Bare Wires and Cables



Steel Strand Used as Conductors on Long Distance Transmission Line

Properties of Special Grades Extra Galvanized Special Strands

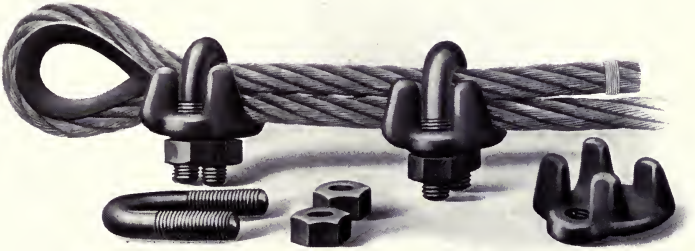
Diameter of Strand, Inches	Number of Wires in Strand	Strength S. M. Strand Tons	Strength Crucible Strand Tons	Strength Plow Strand Tons	Approximate Weight per Foot Pounds
1½	61	55	91.5	121	4.75
1⅜	61	45.5	76	100	3.95
1¼	37	38	63.5	85	3.30
1⅛	37	32.5	54	72	2.62
1	37	25.5	43.7	60	2.25
⅞	19	19	32	45	1.70
¾	19	14.2	23.7	35	1.25
⅝	19	10	16.5	23.5	.81

"Crosby" Wire Rope Clip

Light, durable and convenient. Easily applied. These are galvanized drop-forged clips that securely hold wire rope or strand.

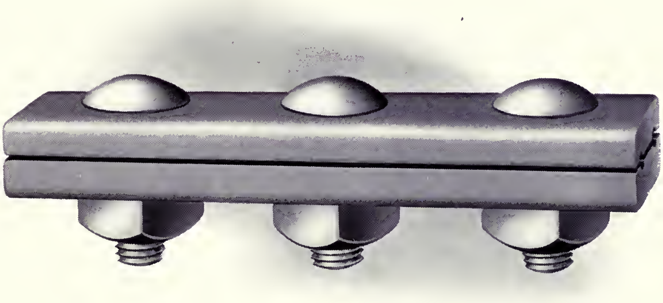
List Prices

Inch	Price	Inch	Price	Inch	Price	Inch	Price	Inch	Price	Inch	Price
¼	$ .35	7/16	$ .45	¾	.65	1⅛	$ .95	1½	$1.50	2	$ 7.50
5/16	.35	½	.45	⅞	.75	1¼	1.10	1⅝	3.50	2¼	9.50
⅜	.40	⅝	.55	1	.85	1⅜	1.25	1¾	5.50	2½	11.50



"Crosby" Wire Rope Clip

Galvanized Three-bolt Strand Clamp



Three-bolt Strand Clamp

This is known as the standard A. T. & T. Co. hot galvanized rolled steel strand clamp or guy clamp; made from open hearth bar steel. Will hold any size of strand from ¼-inch to ½-inch diameter.

Prices on application.

Bare Wires and Cables

Resistance Wire

In conductors used for transmission or distribution purposes, the specific resistance has to be very low so as to avoid consumption of electric energy and a consequent heavy voltage drop in the line. In some constant potential devices, however, such as electric heaters and rheostats, it is desirable to have conductors of very high specific resistance for the express purpose of transforming electrical energy into heat.

We handle a high grade of nickel-steel resistance wire known to the trade as Tico Resistance Wire, made for such purposes where a high specific and uniform resistance is required. In addition to this standard resistance wire, we make many grades and sizes of steel wire that can be used where close regulation is not an essential feature.

Tico Resistance Wire

B. & S. Gauge	Price per Pound	Diameter in Mils	Area Circular Mils	Area Square Inches	Weight Pounds per 1000 Feet	Feet per Pound	Resistance			
							Ohms per Foot	Ohms per Pound	Feet per Ohm	Pounds per Ohm
4	$1.10	204.31	41743	.032784	110.5	9.05	.0124	.112	80.9	8.94
5	1.10	181.94	33102	.025999	87.7	11.40	.0156	.178	64.2	5.63
6	1.10	162.02	26250	.020618	69.54	14.4	.0197	.283	50.8	3.53
7	1.10	144.29	20820	.016351	55.14	18.1	.0248	.450	40.3	2.22
8	1.10	128.49	16510	.012967	43.73	22.9	.0313	.715	32.0	1.40
9	1.10	114.42	13092	.010283	34.68	28.8	.0394	1.14	25.4	.879
10	1.15	101.90	10384	.008155	27.50	36.4	.0497	1.81	20.1	.553
11	1.15	90.74	8234	.006467	21.81	45.8	.0627	2.88	16.0	.348
12	1.15	80.81	6530	.005129	17.70	57.8	.0791	4.57	12.6	.219
13	1.20	71.96	5179	.004067	13.72	72.9	.0997	7.29	10.0	.137
14	1.20	64.08	4107	.003225	10.88	92	.1257	11.6	7.95	.0865
15	1.20	57.07	3257	.002558	8.625	116	.1585	18.4	6.31	.0544
16	1.25	50.82	2583	.002029	6.842	146	.2000	29.2	5.00	.0342
17	1.25	45.26	2048	.001609	5.425	184	.252	46.5	3.97	.0215
18	1.30	40.30	1624	.001276	4.302	232	.318	73.9	3.15	.0135
19	1.30	35.89	1288	.001012	3.411	293	.401	117	2.49	.00851
20	1.30	31.96	1022	.0008023	2.707	369	.505	187	1.98	.00535
21	1.35	28.46	810.1	.0006363	2.146	466	.638	297	1.57	.00337
22	1.35	25.35	642.5	.0005046	1.702	588	.804	473	1.24	.00212
23	1.35	22.57	509.5	.0004002	1.350	741	1.014	751	.986	.00133
24	1.40	20.10	404.1	.0003173	1.070	934	1.278	1194	.782	.000837

Armature Binding Wire

We manufacture tinned steel Armature Binding Wire in large quantities. This is made in four grades designated as A, B, C 1 and C 2, which vary in tensile strength.

Grade A. Used to bind armatures of small motors and dynamos.

Grade B. Commercial grade. Used on motors and dynamos of ordinary commercial size and speed.

Grade C 1. Made of high grade piano wire and used where great strength is required.

Grade C 2. Used when very high tensile strength is required, as on motors and dynamos of unusual size and high speed.

Bare Wires and Cables

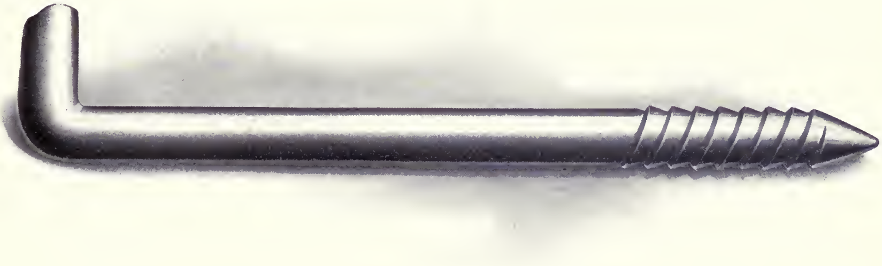
Tensile Strength of Tinned Steel Armature Binding Wire

B. & S. Gauge	Diameter in Mils	Tensile Strength in Pounds. (Minimum)							
		"A" Grade		"B" Grade		"C 1" Grade		"C 2" Grade	
		Actual	Per Sq. In.	Actual	Per Sq. In.	Actual	Per Sq. In.	Actual	Per Sq. In.
10	101.9	938	115,000	1631	200,000	1957	240,000	2447	300,000
11	90.7	743		1292		1551		1938	
12	80.8	590		1026		1231		1538	
13	72.0	468		814		977		1221	
14	64.1	371		645		774		968	
15	57.1	294		512		615		768	
16	50.8	233		405		486		608	
17	45.3	185		322		387		484	
18	40.3	147		255		306		383	
19	35.9	116		202		243		304	
20	32.0	92.5		161		193		241	
21	28.5	73.4		128		153		191	
22	25.3	57.8		101		121		151	
23	22.6	46.1		80.2		96.3		120	
24	20.1	36.5		63.5		76.2		95.2	
25	17.9	28.9		50.3		60.4		75.5	
26	15.9	22.8		39.7		47.7		59.6	

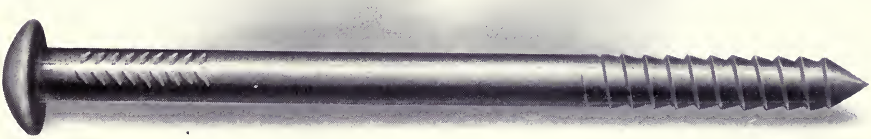
Extra Galvanized Steel Armor Wire for Cables

Made of medium strength steel, extra galvanized, in any size or quantity specified. Used as a protection to the insulation of cables, or to the lead sheathing. This wire is made to conform to the standard specifications of the United States Signal Corps.

Pole Steps



Plain and Extra Galvanized



Button Head Pole Step

Bare Wires and Cables

Pole Steps—Continued

Prices Quoted on Application

Sizes	Approximate Weight per 100 Pole Steps		Sizes	Approximate Weight per 100 Pole Steps	
	Plain	Galvanized		Plain	Galvanized
8 x 5/8 inch	73 pounds	75 pounds	8½ x 9/16 inch	58 pounds	61 pounds
9 x 5/8 inch	78 pounds	81 pounds	9 x 9/16 inch	62 pounds	65 pounds
10 x 5/8 inch	85 pounds	88 pounds	10½ x 9/16 inch	71 pounds	74 pounds
10½ x 5/8 inch	89 pounds	93 pounds	9 x ½ inch	51 pounds	54 pounds

For the use of electric light, street railway and telephone companies.

The above are with our regular spike and button heads.

Lengths given are measurements over all.

Each step carefully threaded with screw thread.

Special shapes or lengths of heads made to order.

A keg of pole steps weighs about 200 pounds.

Silico-Magnetic-Core Steel

This special silicon steel is the best known material for all magnetic core purposes. The permeability of this steel at densities of 12,000 lines per square centimeter or under, is extremely high, thus making it possible to obtain a high magnetization from any given number of ampere turns. Its hysteresis constant is low, and the specific resistance is high—four to five times higher than that of other grades. These properties result in a very low combined hysteresis and eddy current loss.

The material is *non-ageing*. If anything, it improves with age, so that the efficiency of the material remains unimpaired with time of service. These properties combine to make an excellent core material for all kinds of electro-magnets, induction coils, spark coils, and so on.

Drawn to any size, and supplied in any quantities required.

Prices quoted on application.

Magnet Wire

Page
Cotton-covered 85–87
Silk-covered 88
Asbestos and Cotton-covered 89
Rectangular Magnet Wire 89–90
Square Magnet Wire 90
Paper-covered 91
Special Magnet Wire 91
Specifications 91

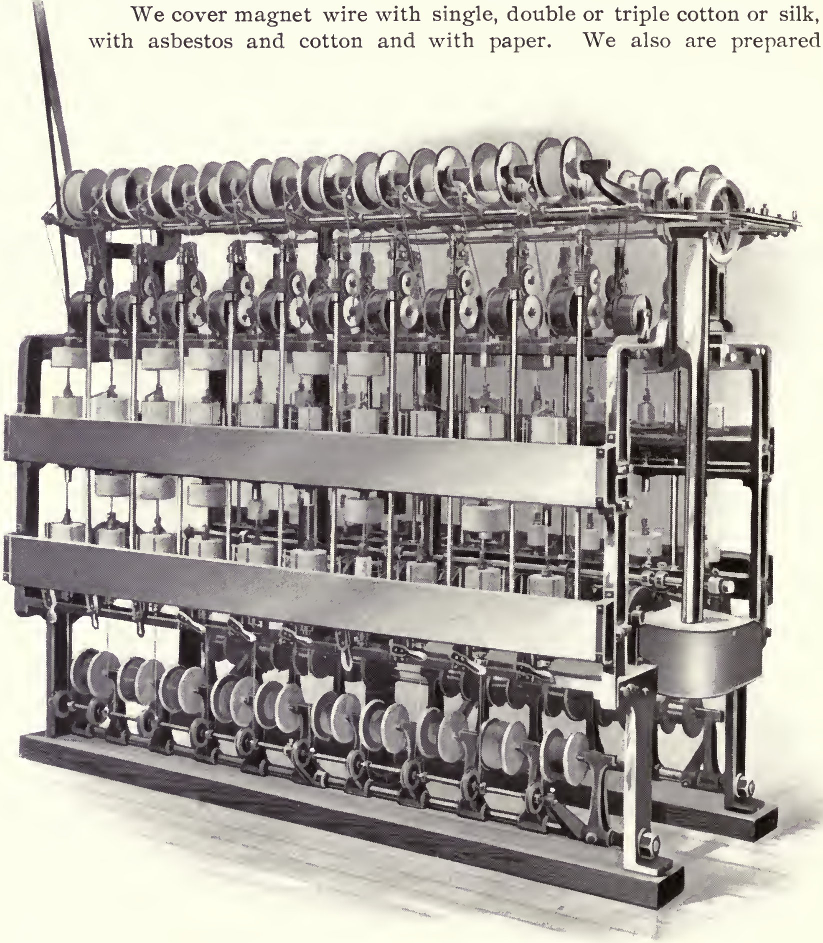
Magnet Wire

Magnet Wire

All copper wire drawn for magnet purposes is thoroughly annealed by processes which insure uniform and extreme softness, highest conductivity and ease of handling. Before the cover is applied all wire is carefully inspected for size and uniformity of dimensions, and to see that it is free from scale and all surface imperfections.

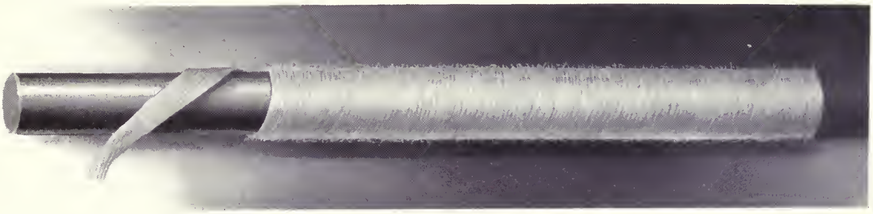
All magnet wire is insulated in special machines by skilled operators. We are not only prepared to produce large quantities of the ordinary commercial sizes of cotton-covered magnet wire, but we are also in a position to and do furnish large amounts of fine and special work, both silk and cotton. The magnet wire is not only inspected during process, for knots, skips, smoothness and evenness of insulation, but it is also given a final thorough inspection and test for continuity before packing. A large supply of the common sizes of magnet wire is constantly kept in stock in our various warehouses.

We cover magnet wire with single, double or triple cotton or silk, with asbestos and cotton and with paper. We also are prepared



Magnet Wire Covering Machine

Magnet Wire



S. C. C. Magnet Wire

to make special kinds of magnet wire which may be specified. The effectiveness of these materials for dielectric purposes depends very largely upon their quality and their freedom from foreign or gritty substances. The covers are wound spirally about the wire, successive layers being wound in opposite directions. Magnet yarn is composed of a number of unit threads called "ends up," which are laid on parallel about the wire. The thickness and evenness of the cover will depend not only upon the quality and size of the thread, but also upon its lay, and this is governed by the relative speed of the spindles and the travel of the wire through the machine.

Cotton. While there are five or six species of cotton having commercial value, the bulk of the product may be divided into two kinds, Upland and Sea Island cotton. The former, which grows over a very wide range of tropical country, has a comparatively coarse staple that seldom reaches 1½ inches in length. The Sea Island species alone is used for magnet purposes, and furnishes the finest and most valuable fibre grown. The staple in this is from 1½ inches to 2½ inches long, and is of a very soft, hairy texture. It produces a soft and even yarn that makes an ideal magnet covering.

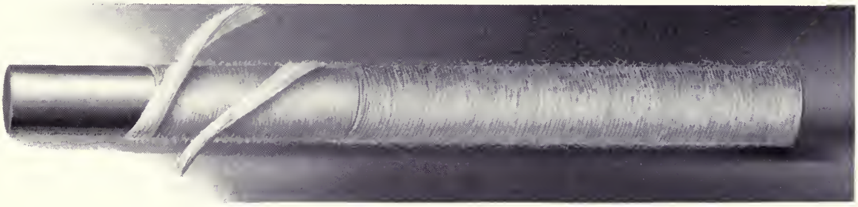
Cotton yarn is *numbered* according to the number of hanks contained in a pound of 7000 grains.

1½ yards = 1 thread or round of the cotton yarn.
120 yards = 80 threads = 1 skein, ley or lea.
840 yards = 560 threads = 7 skeins = 1 hank.

The number of hanks in one pound is the number of the cotton yarn, or the number of cotton yarn equals the number of yards that weigh 8.33 grains.

An *Italian Tram Silk* composed of the finest selected fibres is used to cover all of our silk magnet wire. The silk-worm forms a cocoon of two parallel filaments of silk; three to six cocoons are usually reeled off together, making a thread of raw silk containing six to twelve filaments. One authority states that 500 yards of five twin filaments weigh about 2.5 grains. The number of drachms (27.34 grains) that 1000 yards of this raw silk weighs is the *number* of the silk.

Full dimensions and all properties of copper used for magnet wire will be found fully described on pages 14 and 26.



D. C. C. Magnet Wire

Magnet Wire

Round Cotton-covered Magnet Wire

Advances on Coarse Sizes

Size B. & S.	Single Cotton Covered			Double Cotton Covered			Triple Cotton Covered		Approximate Quantity on Reels Pounds	Number of Reel (See Page 50)
	List Number	Advances Over Base per 100 Pounds	Approximate Pounds per 1000 Feet	List Number	Advances Over Base per 100 Pounds	Approximate Pounds per 1000 Feet	List Number	Advances Over Base per 100 Pounds		
0	5000	Base	321	5100	Base	322	6000	Base	150	321
1	5001	Base	254	5101	Base	256	6001	Base	150	313
2	5002	Base	202	5102	Base	203	6002	Base	150	313
3	5003	Base	160	5103	Base	161	6003	Base	150	313
4	5004	Base	127	5104	Base	128	6004	Base	150	313
5	5005	Base	101	5105	Base	101.5	6005	Base	150	313
6	5006	Base	80.1	5106	Base	80.6	6006	Base	150	313
7	5007	$0.25	63.6	5107	$0.25	64.1	6007	$0.25	150	313
8	5008	.50	50.4	5108	.75	50.9	6008	.75	150	313
9	5009	.75	40.1	5109	1.25	40.4	6009	1.25	150	313
10	5010	1.00	31.9	5110	1.75	32.1	6010	2.00	150	313
11	5011	1.50	25.3	5111	2.25	25.5	6011	2.75	150	313
12	5012	2.00	20.1	5112	2.75	20.3	6012	3.50	150	313
13	5013	2.50	16	5113	3.50	16.2	6013	4.75	150	313
14	5014	3.00	12.7	5114	4.25	12.9	6014	6.00	150	313
15	5015	3.50	10.1	5115	5.00	10.3	6015	7.25	150	313
16	5016	4.00	7.99	5116	5.75	8.15	6016	8.50	50	338
17	5017	4.50	6.36	5117	6.75	6.51	6017	10.00	50	338
18	5018	5.25	5.05	5118	7.75	5.19	6018	11.50	50	338
19	5019	6.00	4.04	5119	8.75	4.15	6019	13.00	15	343

Fine Sizes Round Magnet Wire

List Price per Pound

Size B. & S.	Single Cotton Covered			Double Cotton Covered			Triple Cotton Covered		Approximate Quantity on Spools Pounds	Number of Spool
	List Number	List Price per Pound	Approx. Pounds per 1000 Feet	List Number	List Price per Pound	Approx. Pounds per 1000 Feet	List Number	List Price per Pound		
20	5020	$0.58	3.22	5120	$0.64	3.33	6020	$0.76	14	343
21	5021	.60	2.57	5121	.70	2.66	6021	.90	13½	343
22	5022	.62	2.03	5122	.74	2.12	6022	.98	13	343
23	5023	.65	1.63	5123	.78	1.70	6023	1.04	12	343
24	5024	.68	1.30	5124	.84	1.37	6024	1.16	11	343
25	5025	.73	1.04	5125	.92	1.11	6025	1.30	4½	347
26	5026	.80	.822	5126	1.00	.898	6026	1.40	4	347
27	5027	.86	.662	5127	1.10	.730	6027	1.58	4	347
28	5028	.92	.526	5128	1.20	.588	6028	1.76	4	347
29	5029	.98	.428	5129	1.30	.485	6029	1.94	4	347
30	5030	1.08	.337	5130	1.42	.383	6030	2.22	2	345
31	5031	1.19	.274	5131	1.54	.318	6031	2.38	2	345
32	5032	1.27	.222	5132	1.64	.264	6032	2.44	2	345
33	5033	1.44	.181	5133	1.88	.221	6033	2.76	2	345
34	5034	1.64	.148	5134	2.20	.186	6034	3.32	1½	345
35	5035	1.86	.122	5135	2.50	.147	6035	3.78	1½	345
36	5036	2.12	.101	5136	3.00	.126	6036	4.76	1¼	345
37	5037	2.70	.080	5137	4.30	.109	6037	7.50	1¼	345
38	5038	3.60	.066	5138	5.70	.0884	6038	9.90	1	345
39	5039	4.70	.056	5139	7.20	.0762	6039	12.20	1	345
40	5040	6.00	.048	5140	9.00	.0665	6040	15.00	1	345

Magnet Wire

Round Cotton-covered Magnet Wire

Coarse Sizes

Size B & S.	Diameter Inches	Allowable Variation Either Way in Per Cent.	Rated Area in Cir. Mils.	Single Cotton Covered Approximate Values		Double Cotton Covered Approximate Values	
				Outside Diameter Inches	Feet per Pound	Outside Diameter Inches	Feet per Pound
0	0.3249	½ of 1	105,625	.333	3.1	.339	3.1
1	.2893	½ of 1	83,694	.297	3.9	.303	3.9
2	.2576	½ of 1	66,358	.266	5.	.272	4.9
3	.2294	¾ of 1	52,624	.237	6.2	.243	6.2
4	.2043	¾ of 1	41,738	.212	7.8	.218	7.8
5	.1819	¾ of 1	33,088	.190	9.9	.196	9.9
6	.1620	¾ of 1	26,244	.170	12.5	.176	12.4
7	.1443	¾ of 1	20,822	.152	15.7	.158	15.6
8	.1285	1	16,512	.136	19.8	.142	19.6
9	.1144	1	13,087	.121	24.9	.125	24.7
10	.1019	1	10,384	.108	31.4	.113	31.1
11	.0907	1	8,226	.097	39.5	.102	39.1
12	.0808	1¼	6.528	.087	49.6	.092	49.2
13	.0720	1¼	5,184	.078	62.5	.083	61.7
14	.0641	1¼	4,108	.070	78.6	.075	77.5
15	.0571	1½	3,260	.063	98.9	.068	97
16	.0508	1½	2,580	.056	125	.060	122
17	.0453	1½	2,052	.050	157	.054	153
18	.0403	1½	1,624	.045	198	.050	192
19	.0359	1¾	1,288	.041	248	.045	240

Fine Sizes

Size B. & S.	Diameter Inches	Allowable Variation Either Way in Per Cent.	Rated Area in Cir. Mils.	Single Cotton Covered Approximate Values		Double Cotton Covered Approximate Values	
				Outside Diameter Inches	Feet per Pound	Outside Diameter Inches	Feet per Pound
20	0.0320	1¾	1,024	0.0365	311	.0410	300
21	.0285	1¾	812.2	.0330	389	.0375	376
22	.0253	1¾	640.0	.0298	492	.0343	473
23	.0226	2	510.7	.0271	613	.0316	588
24	.0201	2	404.0	.0246	769	.0291	729
25	.0179	2	320.4	.0224	961	.0269	900
26	.0159	2	252.8	.0204	1217	.0249	1114
27	.0142	2	201.6	.0187	1510	.0232	1370
28	.0126	2	158.7	.0171	1900	.0216	1700
29	.0113	2	127.6	.0158	2336	.0203	2060
30	.0100	2½	100.0	.0140	2967	.0190	2611
31	.0089	3	79.74	.0129	3650	.0179	3144
32	.0080	3	63.20	.0120	4504	.0169	3788
33	.0071	3	50.13	.0111	5525	.0160	4520
34	.0063	3½	39.69	.0103	6756	.0153	5376
35	.0056	4	31.47	.0096	8197	.0141	6803
36	.0050	4½	25	.0090	9901	.0135	7937
37	.0045	5	19.80	.0084	12500	.0129	9174
38	.0040	6	15.68	.0085	15151	.0119	11310
39	.0035	7	12.46	.0075	17857	.0115	13120
40	.0031	8	9.860	.0071	20833	.0111	15037

Magnet Wire

Fine Sizes Silk-covered Round Magnet Wire

List Price per Pound

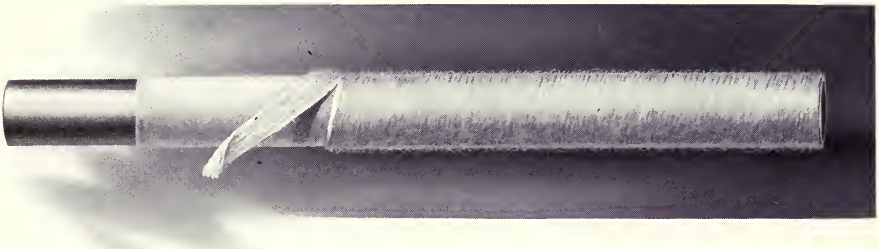
Size B. & S.	Single Silk			Double Silk			Triple Silk		Number of Spool (See Page 50)	Two Covers Silk and Cotton
	List Number	Approximate Quantity on Spools Pounds	List Price per Pound	List Number	Approximate Quantity on Spools Pounds	List Price per Pound	List Number	List Price per Pound		
20	5220	14	$0.88	5320	13	$1.12	6120	$1.24	343	$0.94
21	5221	13½	.90	5321	12	1.15	6121	1.26	343	1.00
22	5222	13	.92	5322	11	1.22	6122	1.34	343	1.04
23	5223	12	.96	5323	10	1.28	6123	1.44	343	1.09
24	5224	11	1.02	5324	9	1.38	6124	1.62	343	1.18
25	5225	6	1.10	5325	5	1.48	6125	1.88	347	1.29
26	5226	6	1.20	5326	5	1.65	6126	2.10	347	1.40
27	5227	5	1.30	5327	4	1.85	6127	2.38	347	1.54
28	5228	4½	1.40	5328	4	2.00	6128	2.76	347	1.66
29	5229	4½	1.53	5329	4	2.22	6129	3.40	347	1.80
30	5230	2½	1.70	5330	2	2.56	6130	4.48	345	2.00
31	5231	2½	1.92	5331	2	3.08	6131	5.72	345	2.18
32	5232	2	2.16	5332	1¾	3.40	6132	6.24	345	2.38
33	5233	2	2.46	5333	1¾	4.00	6133	7.52	345	2.68
34	5234	1¾	2.90	5334	1½	4.60	6134	8.72	345	3.10
35	5235	1½	3.38	5335	1¼	5.28	6135	9.24	345	3.52
36	5236	1½	3.93	5336	1¼	5.98	6136	10.00	345	4.28
37	5237	1¼	4.66	5337	1	7.37	6137	11.40	345	5.80
38	5238	1¼	5.58	5338	1	8.43	6138	12.40	345	7.00
39	5239	1	6.76	5339	¾	9.75	6139	14.60	345	8.70
40	5240	1	8.14	5340	¾	11.53	6140	16.40	345	11.00

Properties of Fine Sizes Silk-covered Round Magnet Wire

Size B. & S.	Diameter Inches	Area Cir. Mils.	Single Silk			Double Silk		
			Maximum Outside Diameter Inches	Approximate Feet per Pound	Approximate Pounds per 1000 Feet	Maximum Outside Diameter Inches	Approximate Feet per Pound	Approximate Pounds per 1000 Feet
20	.0320	1,024	.0340	316	3.160	.0360	313	3.190
21	.0285	812.2	.0305	398	2.510	.0325	393	2.543
22	.0253	640.0	.0273	502	1.990	.0293	492	2.013
23	.0226	510.7	.0246	632	1.581	.0266	623	1.604
24	.0201	404	.0221	796	1.257	.0241	781	1.280
25	.0179	320.4	.0199	1000	1.000	.0219	977	1.023
26	.0159	252.8	.0179	1258	.794	.0199	1233	.811
27	.0142	201.6	.0162	1569	.637	.0182	1531	.653
28	.0126	158.7	.0146	1996	.501	.0166	1934	.517
29	.0113	127.6	.0133	2463	.406	.0153	2380	.420
30	.0100	100.0	.0120	3125	.320	.0140	3003	.333
31	.0089	79.70	.0109	3906	.256	.0129	3731	.268
32	.0080	63.20	.0100	4878	.205	.0120	4651	.215
33	.0071	50.13	.0091	6060	.165	.0111	5714	.175
34	.0063	39.69	.0083	7575	.132	.0103	7092	.141
35	.0056	31.47	.0076	9433	.106	.0096	8695	.115
36	.0050	25	.0070	11627	.086	.0090	10637	.094
37	.0045	19.80	.0065	14492	.069	.0085	12987	.077
38	.0040	15.68	.0060	17857	.056	.0080	15625	.064
39	.0035	12.46	.0055	22222	.045	.0075	18518	.054
40	.0031	9.860	.0051	27027	.037	.0071	22222	.045

Magnet Wire

Asbestos and Single Cotton-covered



Round Asbestos and S. C. C. Magnet Wire

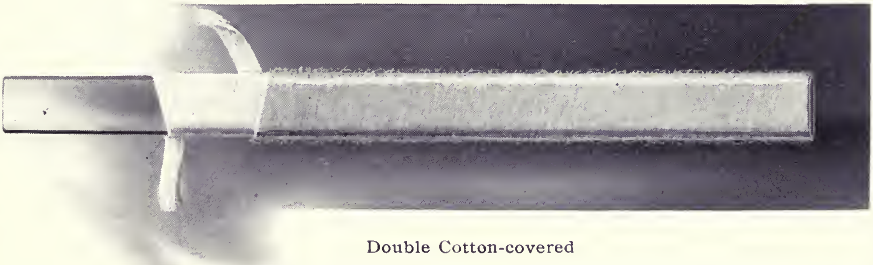
Order by List Numbers

Size B. & S.	List Number for Asbestos and Single Cotton Cover	Approximate Pounds per 1000 Feet	Approximate Diameter Over Insulation Inches	Approximate Quantity on Reels Pounds	Round Asbestos and Single Cotton Covered Advances Over Base per 100 Pounds	Round Asbestos and Double Cotton Covered Advances Over Base per 100 Pounds Special	Shipped on Reels Number
0000	5440	. .	.482	150	Base	Base	321
000	5430	. .	.432	150	Base	Base	321
00	5420	. .	.387	150	Base	Base	321
0	5400	325	.347	150	Base	Base	321
1	5401	258	.311	150	Base	Base	313
2	5402	205	.280	150	Base	Base	313
3	5403	163	.251	150	Base	Base	313
4	5404	130	.226	150	Base	Base	313
5	5405	103	.204	150	Base	Base	313
6	5406	82	.184	150	Base	Base	313
7	5407	66	.166	150	$0.25	$0.25	313
8	5408	52	.150	150	.75	.75	313
9	5409	42	.136	150	1.25	1.25	313

A very thin asbestos tape is first applied to the wire. This tape is strong and flexible and uniform in texture. It serves as an excellent fire protection. Over this asbestos is wound one or sometimes two covers of cotton. This magnet wire is used largely for railway motor purposes.

For information regarding reels, see page 50.

Rectangular Magnet Wire



Double Cotton-covered

Magnet Wire

Rectangular Magnet Wire—Continued

Size Square Mils	Advances per 100 Pounds	Size Square Mils	Advances per 100 Pounds	Size Square Mils	Advances per 100 Pounds
30,001 and over	Base	8,001 to 9,000	$4.75	2,501 to 3,000	$16.75
25,001 to 30,000	$0.25	7,001 to 8,000	5.75	2,001 to 2,500	21.75
20,001 to 25,000	.75	6,001 to 7,000	6.75	1,501 to 2,000	28.75
15,001 to 20,000	1.75	5,001 to 6,000	8.75	1,001 to 1,500	43.75
10,001 to 15,000	2.75	4,001 to 5.000	10.75	501 to 1,000	63.75
9,001 to 10,000	3.75	3,001 to 4,000	13.75	500 and under	88.75

To obtain size in square mils, when width and thickness are given, multiply the dimensions in mils.

Example. 340 mils wide × 40 mils thick = 13,600 square mils. Circ. mils is obtained by dividing square mils by 0.7854.

Square Magnet Wire

Square Magnet Wire D. C. C.

Order by List Numbers

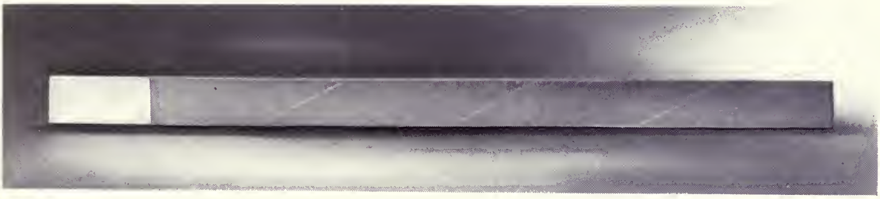
Size B. & S.	List Number	Approximate Radius of Corners Inches	Approximate Diameter Over Insulation Double Cotton Covered	Approximate Quantity on Reel Pounds	Square Double Cotton Covered Advances Over Base per 100 Pounds	Square Triple Cotton Covered Advances Over Base per 100 Pounds	Shipped on Reel Number
0000	5540	1/16	.481	150	Base	Base	321
000	5530	1/16	.431	150	Base	Base	321
00	5520	1/16	.386	150	Base	Base	321
0	5500	1/16	.346	150	Base	Base	321
1	5501	1/16	.310	150	Base	Base	313
2	5502	1/16	.279	150	Base	Base	313
3	5503	1/16	.250	150	Base	Base	313
4	5504	3/64	.225	150	Base	Base	313
5	5505	3/64	.200	150	Base	Base	313
6	5506	1/32	.180	150	$0.25	$0.25	313
7	5507	1/32	.163	150	.75	.75	313
8	5508	1/32	.146	150	1.25	1.25	313
9	5509	.02	.130	150	1.75	2.00	313
10	5510	.02	.117	150	2.25	2.75	313
11	5511	.02	.106	150	2.75	3.50	313
12	5512	.02	.096	150	4.00	5.25	313
13	5513	.02	.087	150	4.75	6.50	313

Each side measures the same as the diameter of round wire of corresponding gauge number.

Copper 98 per cent. conductivity and annealed extremely soft. Used largely in street railway motors. Full dimensions of reels given on page 50.

Paper-covered Magnet Wire

To reduce the amount of space taken up by the insulation of double cotton-covered magnet wire, we have perfected machinery for covering wire with a very thin paper insulation. The space required by this paper insulation is less than half that required for a double cotton covering, thus allowing more ampere turns in a given space. The paper remains in place when the wire is bent to a short radius and does not readily carbonize.



Paper-covered Magnet Wire

The very best grade of manila rope paper is used, containing no particles of iron or wood pulp and no trace of alkali or acid. Cheap paper means low dielectric strength and rapid deterioration due to the presence of chemicals in the paper.

This makes a very fine magnet cover, and paper covered magnet wire is used in large quantities for various purposes.

Special Magnet Wire

We are well prepared to supply special magnet wire that may be required for any unusual purpose. We mention here only a few of such types which we make.

Round duplex magnet wire in which both conductors either bare or insulated, are laid parallel and covered with one, two or three coverings of silk or cotton.

Magnet wire also furnished with stranded conductor, if desired.

We supply tinned magnet wire in any shape.

We solicit your correspondence and shall be pleased to quote you on magnet wire made to any of the above special requirements. Special attention given to the manufacture of magnet wire to the customers' own specifications.

Specifications for Cotton-covered Magnet Wire

Annealing. All wire must be thoroughly and uniformly annealed, so as to show the following characteristics on tensile test.

Physical Properties. The wire must be clean and free from all roughness, cracks and laminations, due to making joints or other causes.

Diameter of Wire	Ultimate Tensile Strength per Square Inch Pounds	Elongation in 10 Inches Per Cent.
.0179 inch and smaller	. . . .	Not less than 25
Larger than .0179 inch and smaller than .0508 inch	Not more than 38,000	Not less than 30
.0508 inch and larger	Not more than 36,000	Not less than 32

Magnet Wire

Conductivity. The conductivity of the copper used must not be less than 98 per cent., 100 per cent. conductivity being based on copper having a resistance of 9.59 ohms per circular mil-foot at O° C.

Insulation. The insulation wrappings shall consist of a good quality of cotton yarn. These wrappings must be firmly applied, and free from "skips," and must form a smooth, continuous and uniform insulation at all points on the wire. Successive layers to be wound in opposite directions.

Variation in Dimensions. Bare copper wire must not vary either way from the diameter specified, in excess of the amounts tabulated on page 24.

Insulation. The insulated diameter of the wire must not be greater than that given in the table for cotton-covered wire, page 87.

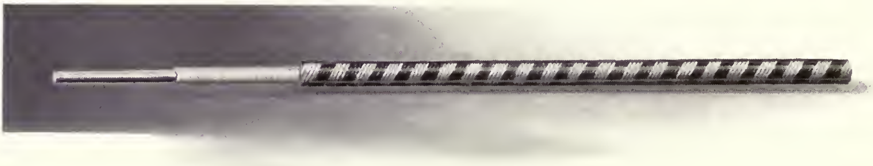
Joints. It is preferred that all wires be furnished in continuous lengths, free from joints; any necessary joints must be so made that the wire at these points is identical in strength, softness and dimensions with the rest of the wire.

Annunciator and Office Wire

Annunciator and Office Wire

Annunciator Wire

This wire as its name implies, is used in primary battery circuits, for call bell or annunciator wiring in hotels, offices or houses. Commercially pure, soft copper wire varying in size from No. 14 B. & S. to No. 22 B. & S. is used. This is insulated with two firm winds of cotton, applied in opposite directions and saturated with our specially prepared paraffine wax compound. The outside wrap is made of any color or combination of colors, the most common being bright and fast red or blue with white. This wire is put up on spools weighing about seven pounds net.



Annunciator Wire

Order by List Number

Size B. & S.	List Number	Advance over Base per 100 Pounds	Approximate Length in One Pound Feet	Size B. & S.	List Number	Advance over Base per 100 Pounds	Approximate Length in One Pound Feet
14	3114	$3.00	67	20	3120	$6.00	221
16	3116	4.00	101	22	3122	8.00	311
18	3118	5.00	155				

"Black Core" or "Damp-proof" Annunciator Wire

Finished in colors as above, shipped on spools of about seven pounds net. This wire is made with the inside wind saturated with our Weatherproof Compound. This permits its use in damp places. The outside wind of cotton which is made in colors is saturated with our special paraffine wax compound, and finished so as to present a smooth and highly polished surface, that will not catch dust.

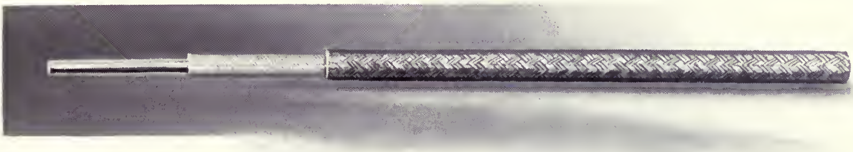
Order by List Number

Size B. & S.	List Number	Advance over Base per 100 Pounds	Approximate Length in One Pound Feet	Size B. & S.	List Number	Advance over Base per 100 Pounds	Approximate Length in One Pound Feet
14	3214	$3.00	60	20	3220	$6.00	200
16	3216	4.00	90	22	3222	8.00	280
18	3218	5.00	130				

Annunciator and Office Wire

Office Wire

Our standard grade of office wire consists of a copper conductor, in size varying from 14 B. & S. to 20 B. & S., insulated with one wind and one braid of cotton both of which are applied tight and even. These two cotton covers are thoroughly saturated with our special paraffine wax compound. The outer braid is given a high polish and is made in any color or combination of colors specified. The standard colors are red and white or blue and white. This wire is put up in coils of about 20 pounds. It is used largely by telephone and telegraph companies for inside wiring, extending from the instruments to the junction where they connect with the outside wires and cables as they enter a building. The wire is also used as a high grade bell and annunciator wire.

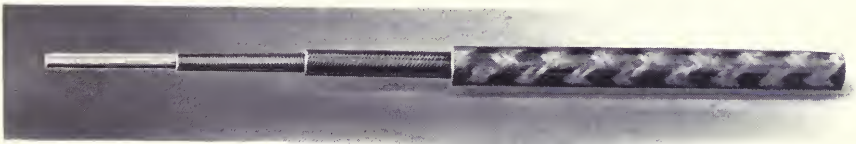


Office Wire

Order by List Numbers

Size B. & S.	List Number	Advance over Base per 100 Pounds	Approximate Length in One Pound Feet	Size B. & S.	List Number	Advance over Base per 100 Pounds	Approximate Length in One Pound Feet
14	3314	$3.00	56	18	3318	$5.00	115
16	3316	4.00	80	20	3320	6.00	154

"Black Core" or "Damp-proof" Office Wire



"Black Core" Office Wire

Order by List Numbers

Size B. & S.	List Number	Advance over Base per 100 Pounds	Approximate Length in One Pound Feet	Size B. & S.	List Number	Advance over Base per 100 Pounds	Approximate Length in One Pound Feet
14	3414	$3.00	53	18	3418	$5.00	98
16	3416	4.00	72	20	3420	6.00	135

Damp-proof office wire has two inside cotton winds applied in opposite directions which are thoroughly impregnated with black weatherproof compound. The outside braid is finished as described above for the regular office wire. This wire is used where a higher grade of insulation is required. It is packed the same as regular office wire.

Annunciator and Office Wire

Special Annunciator and Office Wire

We are prepared to furnish such special kinds of annunciator or office wire as may be specified.

While we have mentioned standard sizes, we can furnish conductors of other sizes, either solid or stranded. Untinned copper wire is used in our regular product, but tinned wire will be furnished if required.

Annunciator and office wire can be *shipped* in special sized packages, ranging from a half-pound to five pounds or over, as may be required, or in coils of specified weights, in cartons, or wrapped in paper and packed in boxes or barrels.

Multiple Conductors

We can supply any of these insulated wires, two in parallel or twisted in pairs, in three-conductor cables or in cables having any number of conductors. Same can be covered with one or more braids or with tape and braid and finished in any manner specified.

Annunciator Wire

Made in any color or combination of colors. Placed on spools containing about seven pounds net

Reliance Weatherproof and Slow Burning Wires and Cables

Copper and Iron

Reliance Weatherproof and Slow Burning Wires and Cables

Weatherproof Wires and Cables

There is a large demand for electrical wires and cables having a moderate degree of insulation and which are less expensive than rubber insulated conductors. For outdoor service our double and triple braid "Reliance" Weatherproof wire meets these requirements in every particular, while for indoor purposes we offer a superior grade of Slow Burning wire. We make wires and cables in strict accordance with all the requirements of the National Board of Fire Underwriters, the sizes varying from No. 20 B. & S. to the largest feeder cables used. Sizes 4/0 B. & S. and smaller are usually made of solid wires, while larger sizes have stranded conductors.

Reliance Weatherproof Feeder Cables

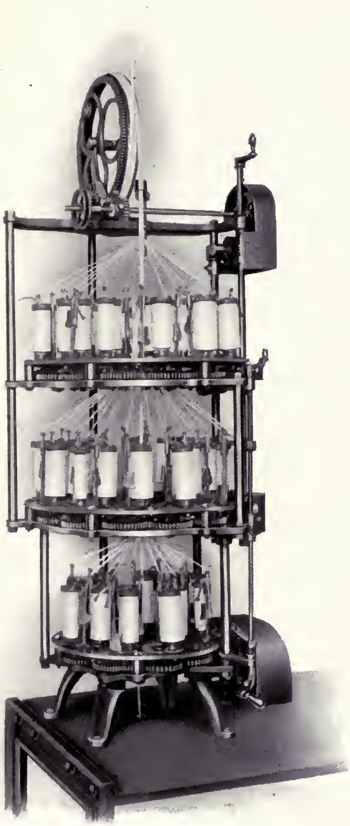
Stranded Copper Conductor—Triple Braid—Black Finish

Unless hard drawn copper be specified, wires of the purest grade of annealed copper, uniform in softness and having a minimum conductivity of 98 per cent. Matthiessen's standard will be used. All the wire used, whether copper or iron, is uniform in section and free from surface imperfections. Complete information regarding the dimensions and properties of bare copper wire will be found on pages 14 and 25, while iron wire will be found fully described on pages 71 to 74.

The insulating material on this class of wire, as will be more fully described below, consists of two or three covers of closely braided fibrous yarn, thoroughly saturated with weatherproof or slow-burning compounds. To combine the three elements, the wire, the braided coverings and the saturating compound so as to produce wires and cables perfectly uniform in weight throughout all portions, would require many refinements which would make the cost prohibitive. In practice it is reasonable and to the advantage of both consumer and manufacturer to allow a variation in weight of approximately 3 per cent. from the tabulated data of weights.

While the National Board of Fire Underwriters specify that the insulation of this class of wire must consist of at least three braids, there are many conditions in which a wire having a good quality of two-braid insulation can be used to advantage.

Reliance Weatherproof and Slow Burning Wires and Cables



Braiding Machine

Reliance Weatherproof Insulation. The wires are first covered by two or three closely and evenly woven braids of strong fibrous material, after which they are placed in a hot bath of weatherproof insulating compound. They remain in this bath long enough to completely and thoroughly saturate the fibrous insulation. After thoroughly drying, the wire then receives a dressing of mineral wax, after which the surface is thoroughly burnished and polished, reducing to a minimum trouble from sleet and ice. The superior grade of compounds used in our Reliance Weatherproof insulation for wires and cables imparts a high degree of dielectric strength, and overcomes the destructive action of the elements. This insulation is firm, durable and tough and possesses great mechanical strength, which enables it to withstand pressure and mechanical abrasion. The compounds contain no solvents which subsequently evaporate, leaving the compound to dry and fall out, thus destroying the insulation. They will withstand all ordinary climatic conditions. This wire is for use outdoors where moisture is certain and where fireproof qualities are not necessary. Also where, on account of small separation, bare wires would be liable to swing into contact with each other or with other low tension cables.

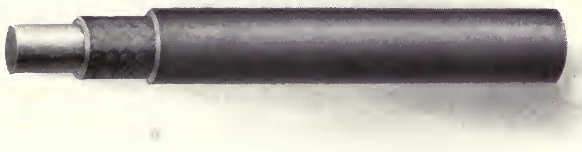
Extracts from the National Board of Fire Underwriters' Rules (1909)

44. Weatherproof Wire.

a. The insulating covering shall consist of at least three braids, all of which must be thoroughly saturated with a dense moisture-proof compound, applied in such a manner as to drive any atmospheric moisture from the cotton braiding, thereby securing a covering to a great degree waterproof and of high insulating power. This compound must retain its elasticity at 0 degrees Fahr. (minus 18 degrees Cent.) and must not drip at 160 degrees Fahr. (71 degrees Cent.). The thickness of insulation must not be less than that given in the table page 100, and the outer surface must be thoroughly slicked down.

Reliance Weatherproof and Slow Burning Wires and Cables

Reliance Weatherproof Wire



Solid Copper Conductor—Double Braid—Black Finish

Order by List Numbers

Size B. & S.	Diameter Inches Bare Wire	Area Circular Mils	List Number	Advance Over Base per 100 Pounds	Approx. Weights Pounds per 1000 Feet	Approx. Weights Pounds per Mile	Standard Packages Approx. Amount Feet	Shipped on Reel Number
0000	460.0	211600	2040	$1.00	723	3,817	2,400	315
000	409.6	167772	2030	1.00	587	3,098	2,500	315
00	364.8	133079	2020	1.00	467	2,467	3,200	315
0	325.0	105625	2000	1.00	377	1,989	4,300	315
1	289.3	83694	2001	1.00	294	1,553	1,000	302
2	257.6	66358	2002	1.00	239	1,264	1,300	302
3	229.4	52624	2003	1.00	185	977	1,600	302
4	204.3	41738	2004	1.00	151	795	2,100	302
5	181.9	33088	2005	1.00	122	646	2,500	322
6	162.0	26244	2006	1.00	100	529	3,400	322
8	128.5	16512	2008	1.00	66	349	5,000	322
9	114.4	13087	2009	2.00	54	283	6,000	322
10	101.9	10384	2010	2.00	46	241	35 to 50	Coils
12	80.8	6528.6	2012	3.00	30	158	25 to 40	Coils
14	64.1	4108.8	2014	4.00	20	107	25 to 40	Coils
16	50.8	2580.6	2016	5.00	16	83	20 to 30	Coils
18	40.3	1624.1	2018	6.00	12	64	20 to 30	Coils

Reliance Weatherproof Wire

Solid Copper Wire—Triple Braid—Black Finish

National Electrical Code Wire

Advances on Weatherproof Wire

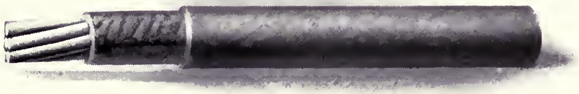
Size B. & S.	Minimum Thickness of Insulation Inches	List Number	Advance Over Base per 100 Pounds	Approx. Weights Pounds per 1000 Feet	Approx. Weights Pounds per Mile	Standard Packages Approx. Amount Feet	Shipped on Reel Number
0000	.0781	2140	Base	767	4,050	2,400	315
000	.0781	2130	Base	629	3,320	2,500	315
00	.0781	2120	Base	502	2,650	3,200	315
0	.0781	2100	Base	407	2,150	4,300	315
1	.0781	2101	Base	316	1,670	1,000	302
2	.0625	2102	Base	260	1,370	1,300	302
3	.0625	2103	Base	199	1,050	1,600	302
4	.0625	2104	Base	164	865	2,100	302
5	.0625	2105	Base	135	710	2,500	322
6	.0625	2106	Base	112	590	3,400	322
8	.0469	2108	Base	75	395	5,000	322
9	.0469	2109	$1.00	62	325	6,000	322
10	.0469	2110	1.00	53	280	35 to 50	Coils
12	.0469	2112	2.00	35	185	25 to 40	Coils
14	.0469	2114	3.00	25	130	25 to 40	Coils
16	.0469	2116	4.00	20	105	20 to 30	Coils
18	.0469	2118	5.00	16	85	20 to 30	Coils

The above standard weights have been adopted because wires having those weights endure longest in service and suit the largest number of customers. Slight variations should be expected in practice.

See page 25 for properties of bare copper wire. Also pages 45 to 50 for information concerning reels and coils.

Reliance Weatherproof and Slow Burning Wires and Cables

Reliance Weatherproof Cables



Stranded Copper Conductors—Double Braid—Black Finish

Order by List Numbers

Size	No. and Diameter of Wires in Strand Inches	Diameter Bare Strand Inches	List Number	Advance Over Base per 100 Pounds	Approximate Weights	
					Pounds per 1000 Feet	Pounds per Mile
2,000,000	91 x .1482	1.6302	2250	$1.25	6690	35,323
1,750,000	91 x .1386	1.5246	2251	1.25	5894	31,119
1,500,000	91 x .1284	1.4124	2252	1.25	5098	26,915
1,250,000	91 x .1172	1.2892	2253	1.25	4264	22,516
1,000,000	61 x .1280	1.1520	2254	1.25	3456	18,246
900.000	61 x .1215	1.0935	2257	1.25	3127	16,513
800,000	61 x .1145	1.0305	2259	1.25	2799	14,779
750,000	61 x .1109	.9981	2260	1.25	2635	13,913
700,000	61 x .1071	.9639	2261	1.25	2471	13,046
600,000	61 x .0992	.8928	2263	1.50	2093	11,052
500,000	37 x .1162	.8134	2265	1.25	1765	9,318
450,000	37 x .1103	.7721	2267	1.25	1601	8,452
400,000	37 x .1040	.7280	2268	1.25	1436	7,584
350,000	37 x .0973	.6811	2269	1.50	1248	6,589
300,000	19 x .1257	.6285	2270	1.25	1083	5,721
250,000	19 x .1147	.5735	2271	1.25	907	4,788
0000	19 x .1055	.5275	2240	1.25	745	3,935
000	19 x .0940	.4700	2230	1.50	604	3,190
00	7 x .1378	.4134	2220	1.25	482	2,544
0	7 x .1228	.3684	2200	1.25	388	2,051
1	7 x .1093	.3279	2201	1.25	303	1,599
2	7 x .0973	.2919	2202	1.50	246	1,301
3	7 x .0867	.2601	2203	1.50	190	1,004
4	7 x .0772	.2316	2204	2.00	155	820
5	7 x .0687	.2061	2205	2.00	126	668
6	7 x .0612	.1836	2206	2.50	103	544
8	7 x .0485	.1455	2208	3.00	68	359

Reliance Weatherproof Cables

Stranded Copper Conductors—Triple Braid—Black Finish

National Electrical Code Wire

Advances on Weatherproof Cables

Size	Minimum Thickness of Insulation Inches	List Number	Advance Over Base per 100 Pounds	Approximate Weights		Standard Packages Approx. Amount Feet	Shipped on Reel Number
				Pounds per 1000 Feet	Pounds per Mile		
2,000,000	.1250	2350	$0.25	7008	37,000	600	324
1,750,000	.1250	2351	.25	6193	32,700	700	324
1,500,000	.1250	2352	.25	5380	28,400	850	324
1,250,000	.1250	2353	.25	4508	23.800	1000	324
1,000,000	.1250	2354	.25	3674	19,400	1320	324
900,000	.1094	2357	.25	3332	17,600	1320	324
800,000	.1094	2359	.25	2992	15.800	1320	324
750,000	.1094	2360	.25	2822	14,900	1320	333
700,000	.1094	2361	.25	2650	14,000	1320	333
600,000	.1094	2363	.50	2235	11,800	1320	333
500,000	.1094	2365	.25	1894	10,000	1320	333
450,000	.0938	2367	.25	1724	9.100	1320	333
400,000	.0938	2368	.25	1553	8,200	1320	333
350,000	.0938	2369	.50	1345	7,100	2640	333
300,000	.0938	2370	.25	1174	6,200	2640	333
250,000	.0938	2371	.25	985	5,200	2640	333
0000	.0781	2340	.25	800	4.220	2000	315
000	.0781	2330	.50	653	3,450	2000	315
00	.0781	2320	.25	522	2.760	2640	315
0	.0781	2300	.25	424	2,240	2640	315
1	.0781	2301	.25	328	1,735	1000	302
2	.0625	2302	.50	270	1,425	1300	302
3	.0625	2303	.50	206	1.090	1600	302
4	.0625	2304	1.00	170	900	2100	302
5	.0625	2305	1.00	140	740	3000	322
6	.0625	2306	1.50	115	610	3400	322
8	.0469	2308	2.00	78	410	4000	322

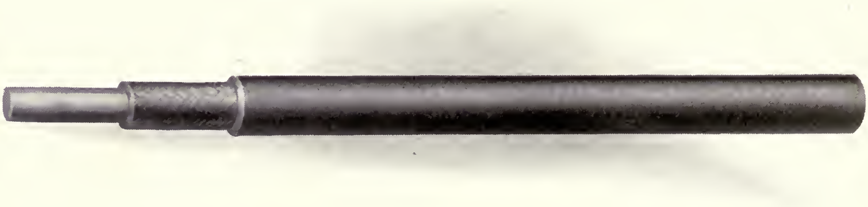
The above standard weights have been adopted because wires having those weights endure longest in service and suit the largest number of customers. Slight variations should be expected in practice. The construction and properties of stranded copper conductors are described on pages 29 to 31. See page 50 for information concerning reels.

Reliance Weatherproof and Slow Burning Wires and Cables

Data Concerning Solid Copper Weatherproof Coils

Size B. & S.	Approximate Weight per Coil, Pounds		Approximate Outside Diameter of Coil Inches	Approx. Diameter of Eye of Coil Inches	Approx. Thickness of Coil Inches	Covering of Coil	How Shipped
	2 Braids	3 Braids					
0000	360	383	30 to 34	19	7½	Paper and Burlap	Loose Coils
000	352	377	30 to 34	19	7½		
00	326	350	30 to 34	19	7½		
0	301	325	30 to 34	19	7½		
1	294	316	30 to 34	19	7½		
2	310	338	30 to 34	19	7½		
3	305	330	30 to 34	19	7½		
4	317	344	30 to 34	19	7½		
5	317	350	30 to 34	19	7½		
6	320	180	30 to 34	19	6		
8	171	195	30 to 34	19	6		
10	50	50	18 to 20	12	5	Paper	Coils Packed in Barrels
12	40	40	18 to 20	12	5		
14	40	40	18 to 20	12	5		
16	30	30	18 to 20	12	5		
18	30	30	18 to 20	12	5		

Reliance Weatherproof Iron Wire



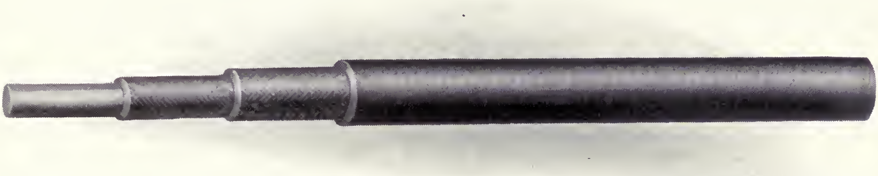
Double Braid

Order by List Numbers Prices Quoted on Application

Size B. W. G.	List Numbers		Approximate Weights per Mile Pounds	Approximate Length of Coil Feet
	B. B. Extra Galvanized	Extra B. B. Extra Galvanized		
4	2704	2804	860	1320
6	2706	2806	665	1760
8	2708	2808	470	2640
9	2709	2809	400	2640
10	2710	2810	350	2640
12	2712	2812	225	2640
14	2714	2814	145	2640
16	2716	2816	100	5280
18	2718	2818	65	5280

Reliance Weatherproof and Slow Burning Wires and Cables

Reliance Weatherproof Iron Wire



Triple Braid

Order by List Numbers

Size B. W. G.	List Numbers		Approximate Weights per Mile Pounds	Approximate Length of Coil Feet
	B. B. Extra Galvanized	Extra B. B. Extra Galvanized		
4	2904	3004	940	1320
6	2906	3006	740	1760
8	2908	3008	525	2640
9	2909	3009	450	2640
10	2910	3010	400	2640
12	2912	3012	260	2640
14	2914	3014	175	2640
16	2916	3016	125	5280
18	2918	3018	85	5280

USES. For fire alarm, telephone, telegraph and burglar alarm construction, where danger of short circuits with other wires or trees exists.

Data Concerning Weatherproof Iron Wire Coils

Size B. W. G.	Approximate Weight per Coil Pounds		Approx. Outside Diameter of Coil Inches	Approx. Diameter of Eye of Coil Inches	Approximate Thickness of Coil Inches		Covering of Coil	How Shipped	Approx. Length in a Coil Feet
	2 Braids	3 Braids			2 Braids	3 Braids			
6	222	247	30 to 34	19	6	7½	Paper and Burlap	Loose Coils	1760
8	235	263	30 to 34	19	6	7½			2640
9	200	225	30 to 34	19	6	7½			2640
10	175	200	30 to 34	19	6	7½			2640
12	113	130	30 to 34	19	6	7½			2640
14	78	87	22 to 24	12	5	5			2640

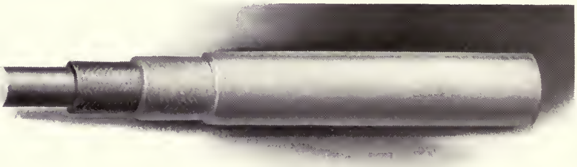
Reliance Weatherproof and Slow Burning Wires and Cables

Reliance Slow Burning Wires and Cables

This, as its name implies, has an insulation that will not carry flame. It is especially useful in hot, dry places where ordinary insulations would perish, and where wires are brought together, as on the back of a large switchboard or in a wire tower, where the accumulation of rubber or weatherproof insulations would result in an objectionably large mass of highly inflammable material.

This wire is made in strict accordance with the requirements of the National Board of Fire Underwriters in all respects.

The insulation is somewhat similar to that on the old so-called "Underwriters" wire. Each insulating braid is completely saturated with our white slow burning compound, and the outside is thoroughly slicked down and given a hard, smooth, white surface.



Solid Conductor—Triple Braid—White Finish

National Electrical Code Standard

Order by List Numbers Prices Quoted on Application

*Size	Stranded				Solid				Standard Packages Approx. Amounts Feet	Shipped on Reel Number (See Page 50)
	List Number	Advance Over Base per 100 Pounds	Approx. Weights		List Number	Advance Over Base per 100 Pounds	Approx. Weights			
			Pounds per 1000 Feet	Pounds per Mile			Pounds per 1000 Feet	Pounds per Mile		
2000000	2400A	$0.75	7540	39800	. .	. .	. .	. .	600	. .
1750000	2401A	.75	6700	35400	. .	. .	. .	. .	700	. .
1500000	2402A	.75	5830	30800	. .	. .	. .	. .	850	. .
1250000	2403A	.75	4940	26100	. .	. .	. .	. .	1000	. .
1000000	2404A	.75	3980	21000	. .	. .	. .	. .	1320	324
900000	2406A	.75	3640	19200	. .	. .	. .	. .	1320	324
800000	2408A	.75	3280	17300	. .	. .	. .	. .	1320	324
700000	2410A	.75	2920	15400	. .	. .	. .	. .	1320	333
600000	2412A	1.00	2460	13000	. .	. .	. .	. .	1320	333
500000	2414A	.75	2080	11000	. .	. .	. .	. .	1320	333
450000	2415A	.75	1900	10000	. .	. .	. .	. .	1320	333
400000	2416A	.75	1700	9000	. .	. .	. .	. .	1320	333
350000	2417A	1.00	1500	7900	. .	. .	. .	. .	2640	333
300000	2418A	.75	1310	6900	. .	. .	. .	. .	2640	333
250000	2419A	.75	1120	5900	. .	. .	. .	. .	2640	333
0000	2640	.75	960	5070	2440	$0.50	925	4890	2000	315
000	2630	1.00	785	4150	2430	.50	760	4020	2000	315
00	2620	.75	625	3300	2420	.50	600	3170	2640	315
0	2600	.75	510	2700	2400	.50	495	2610	2640	315
1	2601	.75	380	2000	2401	.50	365	1930	1000	302
2	2602	1.00	335	1770	2402	.50	320	1690	1300	302
3	2603	1.00	280	1480	2403	.50	270	1425	1600	302
4	2604	1.50	230	1220	2404	.50	220	1160	2100	302
5	2605	1.50	195	1030	2405	.50	190	1000	2500	322
6	2606	2.00	165	870	2406	.50	160	845	3400	322
8	2608	2.50	105	555	2408	.50	100	530	40-60 lbs.	Coils
10	. .	. .	. .	. .	2410	1.50	80	420	35-50 lbs.	Coils
12	. .	. .	. .	. .	2412	2.50	55	290	25-50 lbs.	Coils
14	. .	. .	. .	. .	2414	3.50	40	210	25-40 lbs	Coils
16	. .	. .	. .	. .	2416	4.50	30	160	25-40 lbs.	Coils
18	. .	. .	. .	. .	2418	5.50	24	130	20-30 lbs.	Coils

*Size and number of wires in strand same as in weatherproof cables, page 101.

Reliance Weatherproof and Slow Burning Wires and Cables

A Specification for Three-braid Weatherproof Wires and Cables

General Description. The finished product desired under these specifications consists of copper, either annealed or hard drawn, covered with weatherproof braids hereinafter specified.

Conductors. Soft drawn copper shall be uniformly annealed and shall have a conductivity of 98 per cent. or higher.

Hard drawn copper shall meet all physical and electrical requirements called for in the specifications for hard drawn copper wire, as given on page **66.**

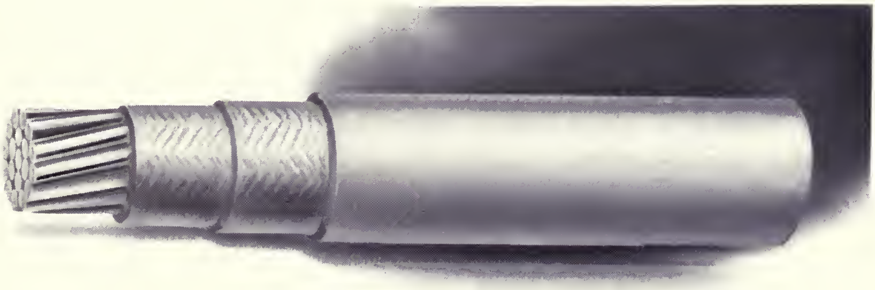
The conductor shall be uniformly cylindrical in form, and free from scales, inequalities, flaws, splints and other imperfections.

The finish of the conductors shall be in accordance with the best commercial practice.

Covering. The conductor shall be covered with not less than three (3) closely woven braids of cotton or other approved material. This braided covering shall be thoroughly saturated with a permanent weatherproof compound, which shall be applied in sufficient quantity to fill all interstices in the braided covering, and shall have a continuous coating of compound over the braided covering.

The weatherproof compound shall be insoluble in water. The compound shall not melt when the finished wire is subjected to a temperature of one hundred and twenty-five (125) degrees Fahrenheit. The compound shall not crack when the wire is subjected to a temperature of ten (10) degrees below zero Fahrenheit, the sample being examined without bending.

The qualities of the compound used and the method of application shall be such as not to injure the covering or the wire.



Stranded Copper Conductor—Triple Braid—White Finish

Special Weatherproof and Slow Burning Wires

Conductors for special purposes are often required to have a combined insulation of black weatherproof and white slow burning coverings. The wires may have a single coating of each kind, or they may have three coatings, two of slow burning and one of weatherproof, or conversely, as may be specified. The several braids are closely and evenly woven and of the proper thickness as required by the National Board of Fire Underwriters.

Reliance Weatherproof and Slow Burning Wires and Cables

When the weatherproof covering is on the inside, the conductor is known generally as "White Finish Weatherproof," and when the flame-proof covering is on the inside it is called "Black Finish Slow Burning." The weatherproof and the slow burning compounds used to impregnate these braids are the same as used on our "Reliance" Weatherproof and Slow Burning wires. In all cases the outside surfaces are finished smooth and hard, and the finished saturated braids present a high degree of insulation and are strong, durable and elastic. The white finish weatherproof wire only is approved by the National Electrical code.

We are also prepared to furnish any of these various kinds of weatherproof or slow burning wires twisted into pairs, or formed into cables having any number of conductors, the conductors so formed being encased in one or more finished braids or with tape and braid as may be specified.

Lamp Cord Products

Page

Lamp Cord 108

Reinforced Portable Cord 110

Cord for Portables 111

Automobile Lighting Cord 111

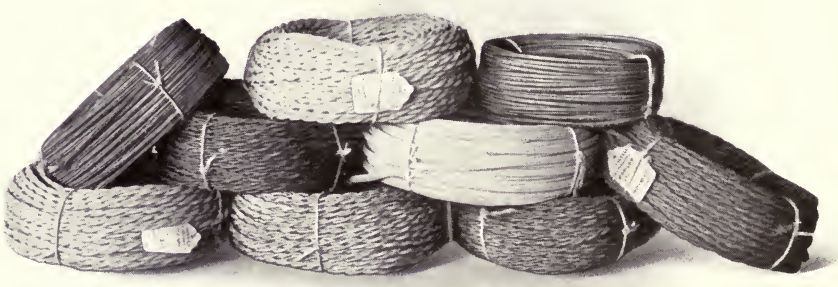
Canvasite Cord 113

American Special Brewery Cord . . 113

Electric Heater Cord 114

Lamp Cord Products

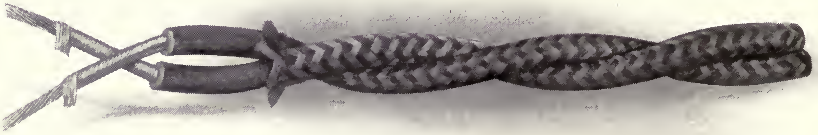
Lamp Cord



Incandescent lamp cord is used in short lengths for exposed wiring in offices and residences to connect the concealed wiring with drop lights, brackets and portables. It is also used for bell and annunciator wiring, and for other purposes where a short flexible connecting conductor having an ornamental insulation would be desirable.

The conductor consists of a number of small untinned annealed copper wires, each No. 30 B. & S. gauge, having a diameter of .01 inch, twisted into a cable of the required carrying capacity. This conductor is then covered with a tight, close wind of fine cotton, after which it is insulated with seamless rubber and then covered with an ornamental braid of silk or cotton. Two of these finished conductors are then twisted about each other, or laid parallel and braided over all with silk or cotton, thus forming the two branches of a circuit. Two grades of lamp cord are made.

Grade "A" Lamp Cord



Grade "A" made to latest National Electrical Code Standard which requires that a solid vulcanized rubber insulation of at least $\frac{1}{32}$ inch thickness be placed over the cotton covering of each conductor. Tested and approved by the Wire Inspection Bureau.

Grade "A" Lamp Cord

Order by List Numbers

Number of Wires in Strand, each No. 30 B. & S.	Equal in Capacity to B. & S.	Cotton Covered List Number	Silk Covered List Number
104	10	4010	4110
65	12	4012	4112
41	14	4014	4114
26	16	4016	4116
16	18	4018	4118
10	20	4020	4120
6	22	4022	4122

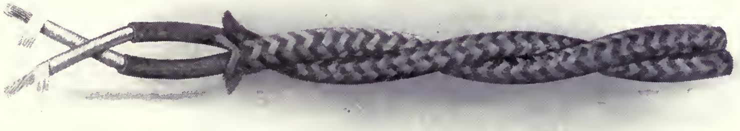
All sizes put up in coils of 250 feet each. Sizes 16 and 18 having largest sale, in packages containing 1000 feet and 3000 feet each, as desired.

A combination of green and yellow is the color usually furnished for outside braid. Other colors to order.

See separate list for prices, page 112.

Grade "C" Lamp Cord

Grade "C" or "Commercial" Lamp Cord made in accordance with the older requirements of the National Electrical Code has a seamless insulation of $\frac{1}{64}$ rubber placed over a tight close wind of fine cotton. The conductors are composed of fine copper wires, No. 30 B. & S. twisted together as in Grade "A," covered with a wind of fine cotton, insulated with rubber, then covered with an ornamental braid of silk or cotton. Two of these finished conductors are then twisted together into a "twisted pair."



Order by List Number

Number of Wires in Strand, each No. 30 B. & S.	Equal in Capacity to B. & S.	Cotton Covered List Number	Silk Covered List Number
104	10	4210	4310
65	12	4212	4312
41	14	4214	4314
26	16	4216	4316
16	18	4218	4318
10	20	4220	4320
6	22	4222	4322

All sizes put up in coils of 250 feet each. Sizes 16 and 18, the sizes having largest sale, in packages containing 1000 feet and 3000 feet as desired.

A combination of green and yellow is the color usually furnished for outside braid. Other colors to order.

The same cotton wound and rubber covered and braided conductors may be laid parallel (instead of twisted) and braided over all, same colors of cotton or silk.

See separate list for prices, page 112.

Reinforced Portable Cord

National Electrical Code Wire

Grade "A"

Made with regular National Electric Code cotton covered lamp cord, over which is placed a supplementary insulation of rubber, making the whole cylindrical. This is covered with one strong braid of silk, dry hard glazed cotton or black waxed cotton. The waxed cotton or "slicked" finish differs from the dry, hard glazed in having the cotton braid thoroughly saturated with weatherproof compound, waxed and polished. Serves as a reinforced or protected lamp cord.

Order by List Numbers

Size B. & S.	Cotton Covered Dry Finish List Number	Silk Covered List Number	Size B. & S.	Cotton Covered Dry Finish List Number	Silk Covered List Number
12	4612	4712	18	4618	4718
14	4614	4714	20	4620	4720
16	4616	4716			

Grade "C"

Made with regular "commercial" cotton covered lamp cord, over which is placed a supplementary insulation of vulcanized $\frac{1}{64}$ rubber, making the whole cylindrical. This is covered with one firm braid of silk, dry glazed or waxed cotton.

Order by List Numbers

Size B. & S.	Cotton Covered Dry Finish List Number	Silk Covered List Number	Size B. & S.	Cotton Covered Dry Finish List Nunber	Silk Covered List Number
12	4612A	4712A	18	4618A	4718A
14	4614A	4714A	20	4620A	4720A
16	4616A	4716A			

Black is the standard color for the outside braid, and will be furnished unless otherwise specified. Special colors to order.

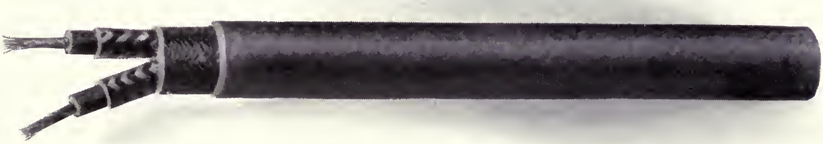
All sizes, both grades put up in coils of 500 feet each.

See separate list for prices, both grades, page 112.

Lamp Cord Products

Cord for Portables

National Electrical Code Wire



Used for portable lamps, small portable motors, or any device which may be carried about. The outer braid is made strong and durable. Made with regular National Electrical Code cotton-covered Grade "A" twisted pair lamp cord, over which is placed a supplementary insulation of vulcanized rubber $\frac{1}{64}$ inch thick, making the whole cylindrical. This is covered with a strong cotton braid thoroughly saturated with weatherproof compound, then waxed and polished.

Order by List Numbers

Size B. & S.	List Number	Size B. & S.	List Number
12	4812	18	4818
14	4814	20	4820
16	4816		

All sizes put up in coils of 500 feet each. This material also made with Grade "C" conductors upon request.

See separate list for prices, page 112.

Automobile Lighting Cord

A cord suitable for wiring to the side and rear lamps of automobiles can be constructed as follows:

Two cotton-covered lamp cord conductors are laid parallel and covered with a strong hard-glazed cotton or a heavy saturated weatherproof cotton braid over the pair. Made of any size conductors specified. Prices quoted on application.

Lamp Cord Products

List Prices for Lamp Cord, Reinforced Portable Cord, and Cord for Portables

Grade "A" National Electrical Code Standard. Grade "C" Commercial (Old Code)

Lamp cord is put up in coils of about 250 feet. Sizes 16 and 18 Brown & Sharpe put up in coils of 250 feet and packed in boxes as follows: No. 1 box, containing 4 coils, total 1,000 feet. No. 2 box, containing 12 coils, total 3,000 feet.

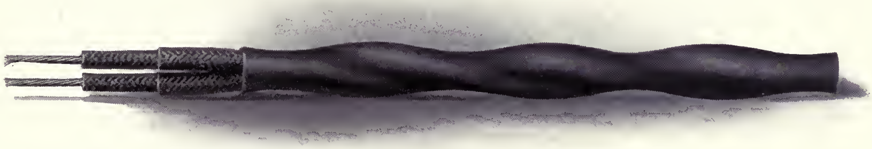
Cord for Portables takes price of cotton covered *Reinforced Portable Cord.*

Standard Schedule Bases in Dollars and Cents per 1000 Feet

Sizes, B. & S.	12c.				13c.				14c.			
	Lamp Cord		Reinforced Cord		Lamp Cord		Reinforced Cord		Lamp Cord		Reinforced Cord	
	Silk	Cotton	Silk	Cotton	Silk	Cotton	Silk	Cotton	Silk	Cotton	Silk	Cotton
10	136.8	105.5	199.3	136.8	140.0	108.8	202.5	140.0	143.5	112.3	206.0	143.5
12	91.5	69.0	154.0	104.0	93.8	71.3	156.3	106.3	95.8	73.3	158.3	108.3
14	66.3	45.0	117.5	76.3	67.3	46.0	118.5	77.3	68.8	47.5	120.0	78.8
16	48.0	30.5	91.8	61.8	48.8	31.3	92.5	62.5	49.5	32.0	93.3	63.3
18	40.5	24.3	79.3	51.8	41.0	24.8	79.8	52.3	41.5	25.3	80.3	52.8
20	35.0	21.3	70.0	45.0	35.3	21.5	70.3	45.3	35.5	21.8	70.5	45.5
22	31.5	17.8	64.0	42.8	31.8	18.0	61.8	43.0	32.0	18.3	64.5	43.3
	15c.				16c.				17c.			
10	146.8	115.5	209.3	146.8	150.0	118.8	212.5	150.0	153.3	122.0	215.8	153.3
12	98.0	75.5	160.5	110.5	100.0	77.5	162.5	112.5	102.0	79.5	164.5	114.5
14	70.0	48.8	121.3	80.0	71.3	50.0	122.5	81.3	72.5	51.3	123.8	82.5
16	50.3	32.8	94.0	64.0	51.3	33.8	95.0	65.0	52.3	34.8	96.0	66.0
18	42.0	25.8	80.8	53.3	42.5	26.3	81.3	53.8	43.0	26.8	81.8	54.3
20	35.8	22.0	70.8	45.8	36.3	22.5	71.3	46.3	36.8	23.0	71.8	46.8
22	32.3	18.5	64.8	43.5	32.5	18.8	65.0	43.8	32.8	19.0	65.3	44.0
	18c.				19c.				20c.			
10	156.5	125.3	219.0	156.5	160.0	128.8	222.5	160.0	163.3	132.0	225.8	163.3
12	104.3	81.8	166.8	116.8	106.3	83.8	168.8	118.8	108.5	86.0	171.0	121.0
14	73.8	52.5	125.0	83.8	75.3	54.0	126.5	85.3	76.3	55.0	127.5	86.3
16	53.0	35.5	96.8	66.8	53.8	36.3	97.5	67.5	54.5	37.0	98.3	68.3
18	43.5	27.3	82.3	54.8	44.0	27.8	82.8	55.3	44.5	28.3	83.3	55.8
20	37.0	23.3	72.0	47.0	37.3	23.5	72.3	47.3	37.5	23.8	72.5	47.5
22	33.0	19.3	65.5	44.3	33.3	19.5	65.8	44.5	33.5	19.8	66.0	44.8
	21c.				22c.				23c.			
10	166.5	135.3	229.0	166.5	169.8	138.5	232.3	169.8	173.0	141.8	235.5	173.0
12	110.5	88.0	173.0	123.0	112.5	90.0	175.0	125.0	114.8	92.3	177.3	127.3
14	77.8	56.5	129.0	87.8	79.0	57.8	130.3	89.0	80.3	59.0	131.5	90.3
16	55.3	37.8	99.0	69.0	56.3	38.8	100.0	70.0	57.0	39.5	100.8	70.8
18	45.0	28.8	83.8	56.3	45.5	29.3	84.3	56.8	46.0	29.8	84.8	57.3
20	38.0	24.3	73.0	48.0	38.5	24.8	73.5	48.5	38.8	25.0	73.8	48.8
22	33.5	19.8	66.0	44.8	33.8	20.0	66.3	45.0	34.0	20.3	66.5	45.3
	24c.				25c.				26c.			
10	176.5	145.3	239.0	176.5	179.8	148.5	242.3	179.8	183.0	151.8	245.5	183.0
12	116.8	94.3	179.3	129.3	119.0	96.5	181.5	131.5	121.0	98.5	183.5	133.5
14	81.8	60.5	133.0	91.8	82.8	61.5	134.0	92.8	84.3	63.0	135.5	94.3
16	57.8	40.3	101.5	71.5	58.5	41.0	102.3	72.3	59.3	41.8	103.0	73.0
18	46.5	30.3	85.3	57.8	47.0	30.8	85.8	58.3	47.5	31.3	86.3	58.8
20	39.0	25.3	74.0	49.0	39.3	25.5	74.3	49.3	39.8	26.0	74.8	49.8
22	34.3	20.5	66.8	45.5	34.5	20.8	67.0	45.8	34.5	20.8	67.0	45.8

Discounts quoted on application

Canvasite Cord



Consists of the regular Code Grade "A" twisted cotton-covered lamp cord, braided over all with one cotton braid saturated with weatherproof compound, then waxed and polished.

Order by List Numbers

Equal to B. & S. G.	List Number	Equal to B. & S. G.	List Number
10	4850	16	4856
12	4852	18	4858
14	4854	20	4860

All sizes put up in coils of 500 feet each. See separate list for prices, page 114.

American (Special) Brewery Cord

Made from the regular Code Grade "A" twisted lamp cord over which is placed a supplementary insulation of vulcanized rubber $\frac{1}{64}$ inch thick. It is then braided over with two heavy cotton braids saturated with weatherproof compound, then waxed and polished. Used for incandescent lighting in breweries and other damp places.

Order by List Numbers

Size B. & S.	List Number	Size B. & S.	List Number
12	4912	18	4918
14	4914	20	4920
16	4916		

All sizes put up in coils of 500 feet each. See separate list for prices, page 114.

Lamp Cord Products

Electric Heater Cord

A flexible cord used for connecting to portable electric heating devices, such as electric sad irons, hair curlers, toasters, etc. No. 31 B. & S. annealed copper wires are braided into a conductor of the required size, cotton wound, rubber insulated and covered with a substantial braid of asbestos, and this is sometimes covered with an outside braid of hard glazed cotton. Two such finished conductors are then twisted into a pair, then covered over all with one or two braids of hard glazed cotton of desired colors. Made in any size or quantity required.

List Prices for American (Special) Brewery and Canvasite Cords

National Electrical Code Standard

Standard Schedule Bases in Dollars and Cents per 1000 Feet

Example: 82.8 Reads $82.80

American (Special) Brewery Cord

Size, B. & S.	12c.	13c.	14c.	15c.	16c.
10	150.5	154.0	157.9	161.5	165.0
12	114.4	116.9	119.1	121.6	123.8
14	83.9	85.0	86.7	88.0	89.5
16	68.0	68.8	69.6	70.4	71.5
18	57.0	57.5	58.1	58.6	59.2
20	49.5	49.8	50.1	50.4	50.9

Size, B. & S.	17c.	18c.	19c.	20c.	21c.
10	168.6	172.2	176.0	179.6	183.2
12	126.0	128.5	130.7	133.1	135.3
14	90.8	92.2	93.8	94.9	96.6
16	72.6	73.5	74.3	75.1	75.9
18	59.7	60.3	60.8	61.4	61.9
20	51.5	51.7	52.0	52.3	52.8

Size, B. & S.	22c.	23c.	24c.	25c.	26c.
10	186.8	190.3	194.2	197.8	201.3
12	137.5	140.0	142.2	144.7	146.9
14	97.9	99.3	101.0	102.1	103.7
16	77.0	77.9	78.7	79.5	80.3
18	62.5	63.0	63.6	64.1	64.7
20	53.4	53.7	53.9	54.2	54.8

Canvasite Cord

Size, B. & S.	12c.	13c.	14c.	15c.	16c.
10	101.0	102.5	104.3	105.8	107.5
12	80.0	81.0	82.3	83.3	84.3
14	64.3	64.8	65.5	66.0	66.8
16	54.8	55.3	55.5	56.0	56.3
18	47.3	47.5	47.8	48.0	48.3
20	39.0	39.3	39.3	39.5	39.8

Size, B. & S.	17c.	18c.	19c.	20c.	21c.
10	109.3	110.8	112.5	114.3	115.8
12	85.3	86.5	87.5	88.5	89.5
14	67.5	68.0	68.5	69.5	70.0
16	56.8	57.3	57.5	58.0	58.3
18	48.5	48.8	49.0	49.3	49.5
20	39.8	40.0	40.0	40.3	40.5

Size, B. & S.	22c.	23c.	24c.	25c.	26c.
10	117.5	119.0	120.8	122.3	124.0
12	90.5	91.5	92.8	93.8	94.8
14	70.8	71.3	72.0	72.5	73.3
16	58.8	59.3	59.5	60.0	60.3
18	49.8	50.0	50.3	50.5	50.8
20	40.8	41.0	41.0	41.3	41.5

Rubber-covered Wires and Cables

Page
Rubber Insulation 116
Application of Rubber Compound . . . 118
Kinds of Insulation 119
Vulcanizing 119
Protection of Insulation 120
Electrical Tests 120
Globe Rubber Insulated Wires and Cables . 124
Telephone Wires and Cables 128
Packing House Cord 131
Elevator Lighting Cables 132
Brewery Cord 132
Border Light Cables 132
Deck Cables 132
Elevator Control Cables 132
Theatre or Stage Cables 133
Crown Rubber Insulated Wires and Cables . 133
Car Cables 138
Mining Machine Cables 139
High Grade 30 Per Cent. Rubber and Special Insulated Wires and Cables 140
Signal Wires and Cables 143
Automobile Ignition Wires and Cables . . 145

Rubber-covered Wires and Cables

Rubber-covered Wires

Rubber-covered wire as used for general purposes comprise three essential parts—the conductor, the wall of rubber insulation, and some form of protection over the rubber, such as braid, tape and braid or sheathing. The conductor consists of uniformly soft annealed commercially pure copper wire. It may be used in the solid form up to size 1/0 B. & S., or in special cases even to 4/0, or in the stranded form. All conductors are thoroughly and evenly coated with tin to protect the copper from making chemical union with any sulphur in the rubber insulation.

Rubber Insulation

There are various grades of crude rubber found in commerce. Rubber producing trees and vines of one kind or another are found in all tropical countries. They belong to widely differing botanical families, and the methods of extracting and preparing the rubber differ also in different countries, hence there is much variation in the qualities of the different crude rubbers, depending chiefly on the kind of impurities, and probably in some degree to obscure differences in the chemical composition of the pure rubber itself. The exact nature of such differences has not yet been definitely explained because of the complexity of the problem.

Crude Rubber

The different grades of crude rubber are known usually under the name of the country or seaport whence they come. Thus we have the terms "Para", "Ceylon," etc., as names of particular grades of rubber.

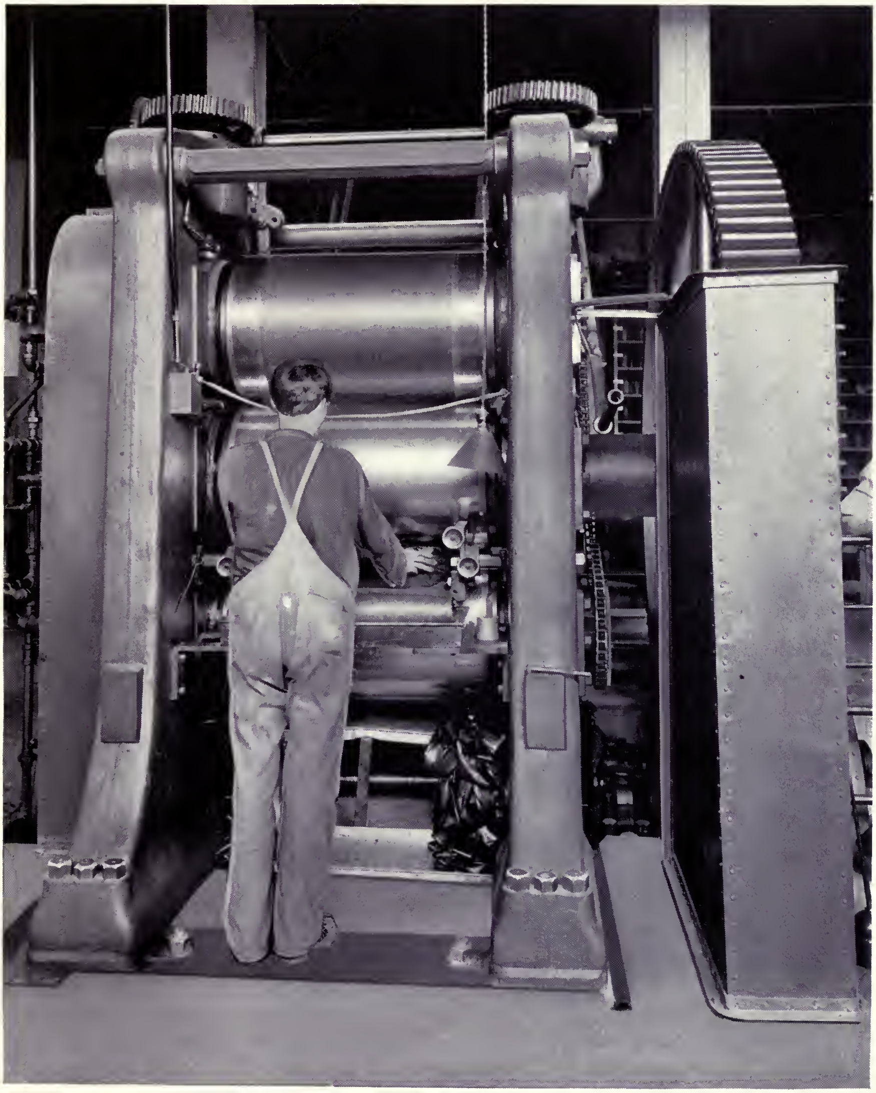
The first step in the preparation of rubber for insulation purposes is to free the crude rubber from impurities, such as bark and sand. This is done by passing it several times between corrugated steel rolls, revolving at different speeds and under a constant stream of water. Thus the rubber is washed clean from such impurities and is delivered in a sheet ready to be dried. There are few practical uses for rubber in its raw condition, for in this state it is most susceptible to physical change, due to external conditions. Crude rubber is affected very much by changes in temperature, hardening with cold, and softening and losing its shape with heat. In this uncured state it readily oxidizes and is particularly susceptible to the action of certain solvents. To obtain the properties needed in the insulation of a wire, the rubber must be compounded with other materials and then vulcanized.

Compounding consists of mixing the rubber with other substances, chiefly powdered minerals, including a small percentage of sulphur. After the crude rubber has been warmed to a plastic condition in the heated mixing rolls, which are smooth and run at different speeds, the compounding ingredients are added to the

Rubber-covered Wires and Cables

rubber and the whole is thoroughly kneaded together by the action of the mixing rolls, until the resulting compound is homogeneous in nature and of suitable physical condition for the work that is expected of it. Another object of compounding is that of economy, the price of pure rubber being relatively high, and it fortunately happens that for insulation purposes a compounded rubber is more suitable than the pure gum.

The composition of the compound and the manner in which it is mixed are matters of prime importance. A practical experience of many years combined with exhaustive tests and experiments have enabled us to develop insulating compounds for various conditions that are unexcelled for serviceability and durability.



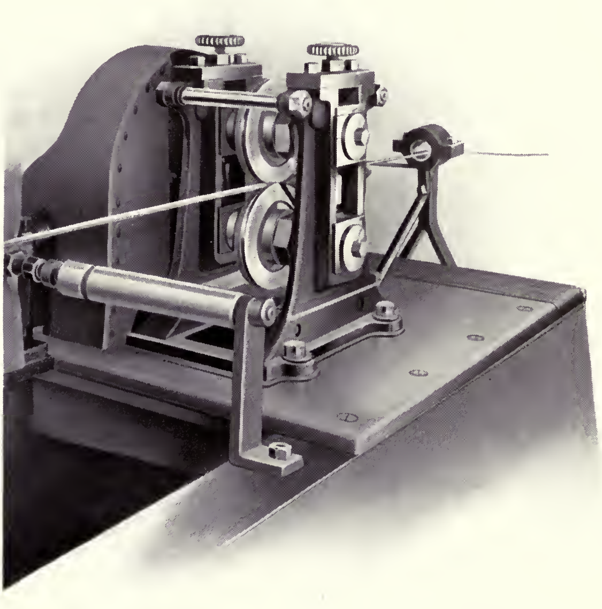
Calenders

Rubber-covered Wires and Cables

Application of the Rubber Compound

A compounded rubber before vulcanizing is plastic, cohesive, but slightly elastic, and can be shaped into any form desired. It is in this condition when applied to the wire. Two different methods are commonly in use for applying the rubber insulation to the wire. In one a machine similar in action to a lead press is used. The rubber is forced by a revolving worm into a closed chamber at high pressure, at the same time being heated by a steam jacket to a soft and plastic state. The wire enters this same chamber through a nozzle of its own diameter, and leaves it from a nozzle having the diameter of the intended insulation. The wire thus comes out with a seamless coating of rubber, forced on at high pressure.

In the other method of application the rubber is sheeted on a calender having heavy smooth rolls, and the sheets thus made are cut into narrow strips, the width and thickness of which depend upon the size of the wire to be insulated and the number of covers to be used. By this method the wire is passed between two or more pairs of grooved rolls running tangent to each other. As the wire enters each pair of rolls, strips of rubber enter at the same time and the grooves fold a uniform thickness of rubber about the wire, the edges meeting in a continuous seam. All surplus rubber is cut off by the rolls at the seams. These seams being made between two pieces of the same unvulcanized cohesive stock under very great pressure, become invisible in the finished wire and can be determined only by a ridge along the insulation. In the process of vulcanizing, the rubber at the seams is kneaded together so that the insulation at this point is as dense and homogeneous as at any other part of the insulation. This is the more generally approved method of insulating wire, particularly high grade wires, and is the method employed for many years by the leading wire manufacturers of the world.



Machine for Applying Rubber Insulation to Wires

A good rubber compound will last indefinitely submerged in pure or salt water, but if the water contains sewage, acids, oils or other destructive agents, then the rubber should be further protected with a lead sheath. If subjected to extremes in temperature or to high temperature combined with wet and dry conditions, or if likely to be injured by external agencies, rubber should be protected with sheathing.

Kinds of Rubber Insulation

We make three standard grades of rubber compound for rubber-covered conductors: *Globe*, or ordinary compound; *Crown*, or intermediate compound; and a *High Grade Thirty Per Cent.* Compound. In addition, we insulate wire to any specifications covering particular requirements such as 20 or 40 per cent. rubber compounds.

Globe Rubber. This is regularly furnished on wires and cables for 600-volt National Electrical Code requirements. It can however be used for potentials as high as 2500 volts, if the service conditions be favorable to rubber, or if the conductor be lead encased.

Crown Rubber. This rubber has better physical properties than the Globe, is more durable, stronger and has a higher factor of safety. It is a high grade compound for all National Electrical Code requirements and can be recommended for service conditions in which the working pressure is 7000 volts or under.

High Grade Thirty Per Cent. Rubber Compound contains only the best grade of pure Para rubber, and is used for high voltage circuits. This makes an unsurpassed dielectric for all high voltages and for exacting service conditions; it has great strength and elasticity, high insulation qualities and long life.

All of these compounds make solid black rubber. We are prepared to furnish a thin white core of rubber containing no sulphur for use next to the copper under any of these compounds when so specified, but we do not recommend this, for years of experience have demonstrated to us that this white core is not needed in connection with our tin-coated wire and black rubber compounds. Every wire insulated with any one of our standard compounds has a distinguishing *tracer thread* embedded in the rubber under the braid. With Globe and 30 Per Cent. Compound, this tracer thread is white in color, while in Crown it is purple.

Vulcanizing

To vulcanize rubber compounds they are subjected to temperatures somewhat above the melting point of sulphur, which temperatures are usually obtained by use of steam under pressure. This operation causes the sulphur in the compound to unite chemically with the rubber and other ingredients of the compound, with the result that the rubber is no longer plastic, but becomes firm, elastic, strong, less susceptible to heat and cold, to the action of the air and less readily affected at ordinary temperatures by the usual solvents of unvulcanized rubber. Its mechanical properties depend considerably on the time and temperature of vulcanization as well as on the amount of sulphur used. As can be readily understood this is an operation that requires a thorough practical knowledge and most constant attention in order that the rubber insulation may have the physical properties that are required under service conditions.

In producing high grade insulation, proper vulcanization is fully as important as the selection of the rubber and ingredients. The process may be compared to that of making bread, no matter how good the dough may be, it has to be baked just right in order to secure good results.

Protection of Insulation

Rubber insulation for most purposes has to be protected by a winding of tape, or by a braid, or a tape and one or more braids, and it is advisable to place some protection on the rubber before vulcanizing the rubber so as to hold the plastic compound in position and to prevent it swelling out of shape and becoming porous during the vulcanizing process. The tape used consists of a good grade of cloth filled with a high class rubber compound. The braiding consists of a strong cotton yarn, knitted tightly and evenly about the insulation by a machine resembling a stocking machine.

The braid is then saturated with a black weatherproof compound, waxed and polished, or it is thoroughly saturated in a white flame-proof compound, and polished, as may be required. It is sometimes specified that the outer braid on wires or cables be of asbestos braid to serve as a fire protection, and this may be saturated either in black or white compound as desired. Or it may consist of a hard cotton of any color or combination of colors.

Electrical and Chemical Laboratories

Our electrical testing department is equipped in the most up-to-date manner for the fulfillment of any conditions likely to be incorporated in the different specifications to which the various kinds of insulated wire and cables are manufactured, as well as to meet the manufacturer's own requirements.

Chemical Laboratory

Rubber-covered Wires and Cables

We have three high potential alternating current testing sets, the largest of which has a capacity of 90 kilowatts and a maximum available pressure of 200,000 volts. These testing sets are in daily use, not only for purposes set forth by purchasers' specifications and the National Electrical Code, but also for our own assurance as to the high electrical quality of our productions.

The high potential tests are followed by tests for insulation resistance and, when required, electrostatic capacity. These are made to prove the soundness of the dielectric, after the application of high voltage. In order to make such tests, the company uses the best apparatus procurable, and applies the most highly scientific methods known. No length of insulated wire or cable is allowed to leave the factory until after it has been found, by the foregoing tests, to be in perfect electrical condition. Special apparatus is also available for the exact measurement of the conductivity of any conductor whether bare or insulated.

Immersion Tanks

The company's tanks, for immersion tests, are supplied by an artesian well, from a depth of about 500 feet. The temperature of this water throughout the year runs very close to 60 degrees Fahrenheit, which in itself is valuable, when it is considered that almost all specifications call for electrical tests at 60 degrees Fahrenheit.

We also have two thoroughly equipped chemical laboratories, one of which is used exclusively for organic chemical research work in connection with insulating materials for our electrical wires and cables.

These laboratories are operated by a corps of practical and highly skilled attendants who have had years of training in their respective lines of investigation.

Rubber-covered Wires and Cables

The Wire Inspection Bureau of New York City inspects every coil of National Electric Code wires made by us. All coils tested and passed by their inspectors carry the certificate of the Wire Inspection Bureau. After ten hours' immersion in water, an alternating current of 1500 volts from a generator of 5 kilowatts capacity is applied to the coil for five seconds. If the insulation successfully withstands this test, the coil is then electrified for one minute with a current of at least 150 volts, and measured for insulation resistance in megohms per mile according to the following table:

Size	Megohms	Size	Megohms	Capacity Circular Mils	Megohms	Capacity Circular Mils	Megohms
14	200	2 and 3	140	250,000 300,000	115	650,000 to 800,000	105
12	180	1	135	350,000 to 600,000	110	850,000 and larger	100
10	160	0	130				
8 and 6	150	00	125				
5 and 4	145	000	120				
		0000	115				

Extracts from 1909 National Electrical Code Rules and Requirements

41. Rubber-covered wire.

a. Copper for conductors must be thoroughly tinned.

Insulation for Voltages, 0 to 600 Inclusive

b. Must be rubber or other approved substances, homogeneous in character, adhering to the conductor, and of a thickness not less than that given in the following table:

Brown & Sharpe Gauge	Thickness, Inch	Circular Mils	Thickness, Inch
18 to 16	$\frac{1}{32}$	250,000 to 500,000	$\frac{3}{32}$
15 to 8	$\frac{3}{64}$	500,000 to 1,000,000	$\frac{7}{64}$
7 to 2	$\frac{1}{16}$	Over 1,000,000	$\frac{1}{8}$
1 to 0000	$\frac{5}{64}$		

Measurements of insulating wall are to be made at the thinnest portion of the dielectric.

c. The complete coverings must show an insulation resistance of at least 100 megohms per mile during thirty days' immersion in water at 70 degrees Fahrenheit (21 degrees Centigrade).

d. Each foot of the completed covering must show a dielectric strength sufficient to resist throughout five minutes the application of an electro-motive force proportionate to the thickness of insulation in accordance with the following table:

Thickness in 64ths of an Inch	Breakdown Test on 1 Foot Volts, Alternating Current	Thickness in 64ths of an Inch	Breakdown Test on 1 Foot Volts, Alternating Current
1	3,000	7	16,500
2	6,000	8	18,000
3	9,000	10	21,000
4	11,000	12	23,500
5	13,000	14	26,000
6	15,000	16	28,000

Rubber-covered Wires and Cables

The source of alternating electro-motive force shall be a transformer of at least one kilowatt capacity. The application of the electro-motive force shall first be made at 4,000 volts for five minutes and then the voltage increased by steps of not over 3,000 volts, each held for five minutes until the rupture of the insulation occurs. The tests for dielectric strength shall be made on a sample of wire which has been immersed in water for seventy-two hours. One foot of the wire under test is to be submerged in a conducting liquid held in a metal trough, one of the transformer terminals being connected to the copper of the wire and the other to the metal of the trough.

Insulation for Voltages, 601 to 3,500 Inclusive

e. The thickness of the insulating wall must not be less than that given in the following table:

Brown & Sharpe Gauge	Thickness, Inch	Circular Mils	Thickness, Inch
14 to 1	$\frac{3}{32}$	250,000 to 500,000	$\frac{3}{32}$ Covered by tape or braid
0 to 0000	$\frac{3}{32}$ Covered by tape or braid	Over 500,000	$\frac{1}{8}$

f. The requirements as to insulation and breakdown resistance for wires for low potential systems shall apply, with the exception that an insulation resistance of not less than 300 megohms per mile shall be required.

Insulation for Voltages Over 3,500

g. Wire for arc light circuits exceeding 3,500 volts potential must have an insulating wall not less than three-sixteenths of an inch in thickness, and shall withstand a breakdown test of at least 23,500 volts and have an insulation of at least 500 megohms per mile.

The tests on this wire to be made under the same conditions as for low potential wires.

Specifications for insulations for alternating currents exceeding 3,500 volts have been considered, but on account of the somewhat complex conditions in such work it has so far been deemed inexpedient to specify general insulations for this use.

General

h. The rubber compound or other approved substance used as insulation must be sufficiently elastic to permit all wires smaller than No. 7 B. & S. gauge and larger than No. 11 B & S. gauge to be bent without injury to the insulation around a cylinder twice the diameter of the insulated wire measured over the outer covering. All wires No. 11 B. & S. gauge and smaller to be bent without injury to the insulation around a cylinder equal to the diameter of the insulated wire measured over the outer covering.

i. All of the above insulations must be protected by a substantial braided covering properly saturated with a preservative compound. This covering must be sufficiently strong to withstand all the abrasions likely to be met with in practice, and must substantially conform to approved samples submitted by the manufacturer.

Rubber-covered Wires and Cables

Shipping of Rubber Insulated and Braided Wire

No. 6 and finer single conductor rubber insulated and braided are shipped in 500-foot coils, having a 12-inch eye, wrapped in paper, and packed in boxes or barrels, unless otherwise specified. Larger sizes as a rule are shipped on reels, as tabulated.

No. 10 and finer duplex parallel rubber insulated and braided are shipped in 500-foot coils, having a 12-inch eye, and in other respects the same as the single conductor.

No. 12 and finer twisted pair rubber insulated and braided are shipped in 500-foot and 1,000-foot coils, and in other respects the same as the single conductor.

Globe Rubber Insulated Wires and Cables

For Incandescent Lighting, Street Railway Feeders, Power Transmission Lines and Telegraph and Telephone Service

The conductivity of all copper used in the manufacture of Globe Wire is 98 per cent. or higher, Matthiessen's standard. All wires are thoroughly annealed, tinned and insulated to meet the requirements of the National Electrical Code Standard. An excellent rubber-covered wire for low potential lines, 600 volts or less. All finished wire is inspected, tested and stamped by the Wire Inspection Bureau.

White distinguishing tracer worsted thread placed between braid and rubber.

Globe Wires

Solid Tinned Copper Conductor, White Finish Rubber Insulated and Braided

National Electrical Code Standard

For Low Potential, 0-600 Volts

Order by List Numbers

Size B & S.	Diam. Bare Wire Inches	Thickness of Rubber Inches	Approximate Diameter		List Number			Standard Packages Approx. Quantities, Feet	Shipped on Reel No.
			Over Single Braid Inches	Over Double Braid Inches	Single Braid Black Finish	Single Braid White Finish	Double Braid Black Finish		
0000	.460	5-64	44-64	47-64	300 C	1200 C	325 C	1000	1002
000	.409	5-64	40-64	43-64	300 B	1200 B	325 B	1000	335
00	.365	5-64	37-64	40-64	300 A	1200A	325A	1000	335
0	.325	5-64	34-64	37-64	300	1200	325	1000	335
1	.289	5-64	32-64	35-64	301	1201	326	1000	334
2	.257	4-64	28-64	31-64	302	1202	327	1000	334
3	.229	4-64	26-64	29-64	303	1203	328	1000	334
4	.204	4-64	24-64	27-64	304	1204	329	1000	1004
5	.182	4-64	23-64	26-64	305	1205	330	1000	1004
6	.162	4-64	21-64	24-64	306	1206	331	500	Coils
8	.128	3-64	17-64	20-64	308	1208	332	500	Coils
10	.102	3-64	15-64	18-64	310	1210	333	500	Coils
12	.081	3-64	14-64	17-64	312	1212	334	500	Coils
14	.064	3-64	13-64	16-64	314	1214	335	500	Coils
16	.051	2-64	10-64	13-64	316	1216	336	500	Coils
18	.040	2-64	9-64	12-64	318	1218	337	500	Coils

Specifications. Solid tinned annealed copper wire of highest conductivity, insulated with code thickness of vulcanized rubber, protected with one or two smooth closely woven cotton braids, saturated with weatherproof compound for outside, or white for inside use, special finish for unlined conduit work. Sizes 14 and larger, inspected and tested by the Wire Inspection Bureau. Regarding reels, see page 50.

Globe Cables

Stranded Tinned Copper Conductor Rubber Insulated and Braided

National Electrical Code Standard

For Low Potential, 0-600 Volts

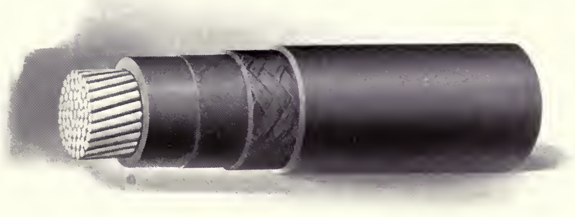
Prices Quoted on Application

Size B.&S.	Number and Diam. of Wires in Strand Inches	Thickness of Rubber Inches	Approximate Diameter		List Number			Standard Packages Approx. Quantities, Feet	Shipped on Reel No.
			Over Single Braid Inches	Over Double Braid Inches	Single Braid Black Finish	Single Braid White Finish	Double Braid Black Finish		
0000	37x.0756	5-64	49-64	52-64	350	1240 C	375	1000	1002
000	37x.0673	5-64	45-64	48-64	351	1240 B	376	1000	335
00	37x.0599	5-64	41-64	44-64	352	1240A	377	1000	335
0	19x.0746	5-64	38-64	41-64	353	1240	378	1000	335
1	19x.0663	5-64	35-64	38-64	354	1241	379	1000	334
2	19x.0592	4-64	30-64	33-64	355	1242	380	1000	334
3	19x.0526	4-64	28-64	31-64	356	1243	381	1000	334
4	7x.0772	4-64	26-64	29-64	357	1244	382	1000	1004
6	7x.0612	4-64	23-64	26-64	358	1246	383	1000	1004
8	7x.0485	3-64	18-64	21-64	359	1248	384	500	Coils
10	7x.0385	3-64	16-64	19-64	360	1250	385	500	Coils
12	7x.0306	3-64	15-64	18-64	361	1252	386	500	Coils
14	7x.0243	3-64	14-64	17-64	362	1254	387	500	Coils
16	7x.0192	2-64	10-64	13-64	363	1256	388	500	Coils

Specifications. Tinned annealed copper strand of highest conductivity, insulated with code thickness of vulcanized rubber, protected with one or two smooth closely woven cotton braids, saturated with weatherproof compound for outside and white for inside use, special finish for unlined conduit work.

Rubber-
covered
Wires
and Cables

Globe Feeder Cables



Stranded Tinned Copper Conductor—Rubber Insulated

National Electrical Code Standard

For Low Potential—0-600 Volts
Order by List Numbers

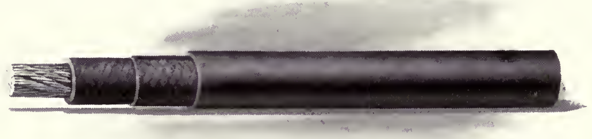
Capacity in Cir. Mils	Number and Diameter of Wires in Conductor Inches	Thickness of Rubber Inches	Approximate Diameter Over Tape and Braid Inches	List Number Single Braid	Shipped on Reel Number
250,000	37 x .0822	3-32	56-64	1380	1013
300,000	37 x .0901	3-32	59-64	1381	1013
350,000	37 x .0973	3-32	62-64	1382	1013
400,000	37 x .1040	3-32	65-64	1383	1013
450,000	37 x .1103	3-32	68-64	1384	1020
500,000	61 x .0905	3-32	72-64	1385	1020
600,000	61 x .0992	7-64	79-64	1386	1020
700,000	61 x .1071	7-64	84-64	1387	1020
800,000	61 x .1145	7-64	88-64	1388	1021
900,000	61 x .1215	7-64	92-64	1389	1021
1,000,000	61 x .1280	7-64	96-64	1390	1021

Specifications. Tinned annealed copper strand of highest conductivity, insulated with code thickness of vulcanized rubber, taped and braided, or taped and covered with a double braid of heavy cotton if desired, saturated in black weatherproof compound for outside, or white for inside use. No. 14 and larger, inspected and tested by the Wire Inspection Bureau.

Shipped on reels containing approximately 1,000-foot lengths.

For electric lighting mains, street railway feeders and power transmission lines.

Globe Flexible Cables



Flexible Tinned Copper Conductor—Rubber Insulated—Black Finish

National Electrical Code Standard

For Low Potential—0-600 Volts
Prices Quoted on Application

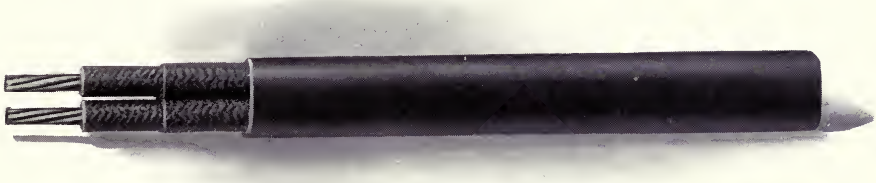
Size B. & S.	Number and Diam. of Wires in Strand Inches	Thickness of Rubber Inches	Approximate Diameter Over		List Number		Standard Packages Approx. Quantities, Feet	Shipped on Reel Number
			Single Braid Inches	Double Braid Inches	Single Braid	Double Braid		
1	259 x .018	5-64	37-64	40-64	951	975	1000	334
2	210 x .018	4-64	33-64	36-64	952	976	1000	334
3	151 x .018	4-64	30-64	33-64	953	977	1000	334
4	133 x .018	4-64	27-64	30-64	954	978	1000	1004
6	82 x .018	4-64	23-64	26-64	956	979	1000	1004
6	49 x .023	4-64	23-64	26-64	956A	979A	1000	1004
8	49 x .0184	3-64	19-64	22-64	958	980	500	Coils
9	40 x .018	3-64	18-64	21-64	959	981	500	Coils
10	19 x .0234	3-64	17-64	20-64	960	982	500	Coils
12	19 x .0185	3-64	15-64	18-64	962	983	500	Coils
14	19 x .0147	3-64	14-64	17-64	964	984	500	Coils

Specifications. Tinned annealed, extra flexible strand of highest conductivity, insulated with code thickness of vulcanized rubber, protected with one or two smooth closely woven cotton braids, saturated in black weatherproof compound, and highly polished.

These wires are for switchboard, brush holder and similar connections where very flexible cables are required.

Regarding reels, see page 50.

Globe Duplex Wires and Cables



Tinned Copper Conductors, Insulated and Braided, Black Finish

Two insulated conductors are laid paralled with one braid over all

National Electrical Code Standard

For low potential, 0-600 volts

Order by List Numbers. Prices Quoted on Application.

Size B. & S.	Thickness of Rubber Inches	Approximate Diameters over Single Braid		List Number		Shipped on Reel Number
		Solid Inches	Strand Inches	Solid	Strand	
0000	5-64	48-64 x 91-64	52-64 x 99-64	1280C	1300C	1020
000	5-64	44-64 x 82-64	48-64 x 92-64	1280B	1300B	1013
00	5-64	41-64 x 77-64	44-64 x 83-64	1280A	1300A	1013
0	5-64	38-64 x 71-64	41-64 x 78-64	1280	1300	1013
1	5-64	35-64 x 66-64	38-64 x 72-64	1281	1301	1002
2	4-64	31-64 x 58-64	34-64 x 63-64	1282	1302	1002
3	4-64	29-64 x 54-64	31-64 x 58-64	1283	1303	1002
4	4-64	28-64 x 51-64	30-64 x 54-64	1284	1304	325
5	4-64	26-64 x 48-64	27-64 x 50-64	1285	1305	335
6	4-64	25-64 x 45-64	26-64 x 48-64	1286	1306	335
8	3-64	21-64 x 31-64	22-64 x 39-64	1288	1308	1004
10	3-64	19-64 x 33-64	20-64 x 35-64	1290	1310	Coils
12	3-64	17-64 x 31-64	18-64 x 32-64	1292	1312	Coils
14	3-64	16-64 x 28-64	17-64 x 29-64	1294	1314	Coils
16	2-64	13-64 x 22-64	14-64 x 23-64	1296	1316	Coils
18	2-64	12-64 x 21-64	. . . . . .	1298	. .	Coils

Specifications. Tinned annealed copper wires or strands of highest conductivity, each conductor insulated with code thickness of vulcanized rubber and protected by saturated tape or braid ; two finished conductors laid parallel, covered with a heavy cotton braid over all, saturated in black weatherproof compound. Special finish for conduit work.

Sizes 14 B. & S. and larger, inspected and tested by the Wire Inspection Bureau.

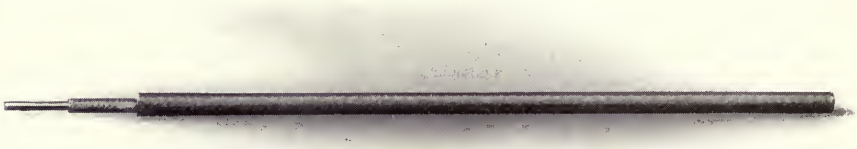
The underwriters' rules permit the use of these wires in conduits, sizes No. 14 and larger. No. 8 and larger shipped on reels containing approximately 1,000-foot lengths, No. 10 and smaller shipped in approximately 500-foot coils.

Regarding reels see page 50.

Rubber-covered Wires and Cables

Globe Fixture Wire

Light Insulation



Solid Tinned Copper Conductor, Rubber Insulation, Single Braid—Black Finish

Size B. & S.	Thickness of Rubber Inches	Approximate Diameter over Braid Inches	List Number	Standard Coils Approximate Quantities Feet
12	1-64	9-64	1362	500
14	1-64	8-64	1364	500
16	1-64	6-64	1366	1000
18	1-64	5-64	1368	1000
19	1-64	5-64	1369	1000
20	1-64	5-64	1370	1000

Specifications. Solid tinned annealed copper wire of highest conductivity, insulated with $\frac{1}{64}$ inch vulcanized rubber, covered with single braid of cotton, saturated in black weatherproof compound, and smoothly polished.

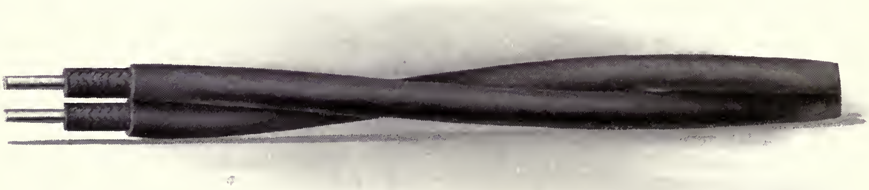
Used only in arms of fixtures not exceeding 24 inches in length, and to supply not more than one 16 candle-power lamp.

For heavy insulation fixture wire, see page 125, list Nos. 312 to 318 inclusive.

Rubber-covered Copper Telephone Wire

While there are many sizes and kinds of conductors under this heading, the following are considered standard by the larger telephone companies:

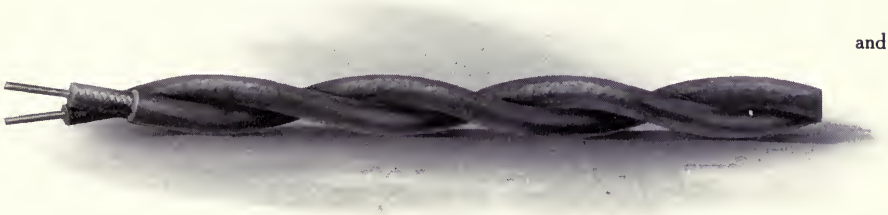
No. 14 B. & S. Twisted Pair "Outside Distributing Wire"



Each conductor hard drawn tinned copper wire, insulated to a diameter of $\frac{5}{32}$ of an inch over rubber and covered with a cotton braid, saturated with black weatherproof compound, wax finish, one conductor having a raised tracer to distinguish it from the other.

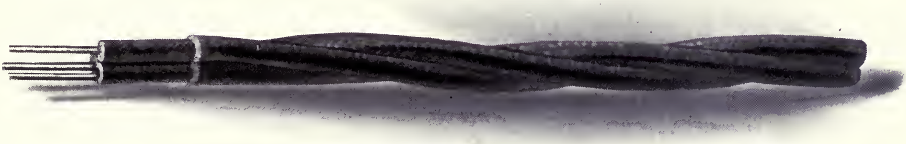
Rubber-
covered
Wires
and Cables

No. 18 B. & S. Twisted Pair "Bridle Wire"



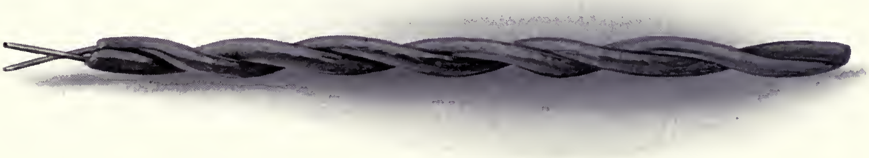
Each conductor soft drawn tinned copper wire, insulated to a diameter of $\frac{7}{64}$ of an inch over rubber and covered with a cotton braid, saturated with black weatherproof compound, wax finish, one conductor having a raised tracer to distinguish it from the other.

No. 19 B. & S. Single Conductor, Twisted Pair, and Triple Conductor "Inside" or "Sub-station" Wire



Conductors soft drawn tinned copper insulated to a diameter of $\frac{3}{32}$ of an inch over rubber, covered with a single hard glazed cotton braid. Single conductors are braided with plain colored cotton, while in the twisted pair one conductor contains a differently colored tracer thread, and in triple conductor two of the three wires contain different colors or different design of tracer threads, thus making no two of the conductor braids alike. Sometimes a differently colored cotton braid is used, one for each conductor, for purposes of distinction.

"Pot Head" Wires, Plain Telephone Conductors



Furnished in the smaller sizes, 18, 19, 20 or 22 B. & S. gauge, either single conductor or twisted pair. Soft tinned copper conductors insulated to a diameter of $\frac{3}{32}$ of an inch over rubber without any outer braid or protection. In case of twisted pairs, one conductor is sometimes made of a differently colored rubber than the other so as to discriminate between them.

Rubber-covered Wires and Cables

The following table includes the foregoing telephone wires and others not otherwise described. Any of the sizes can be furnished in single or multiple conductors.

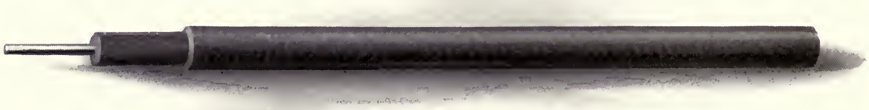
Telephone Wires, Twisted Pairs

Size B. & S.	Finish	Over Rubber	List Numbers			Approximate Weight per 1000 Feet
			No Test	100 Megohms	Over 100 Megohms	
14	Braided	11-64	9141	9040	9040A	75
14	Braided	5-32	9145	9045	9045A	68
16	Braided	5-32	9165	9065	9065A	72
16	Braided	9-64	9169	9069	9069A	55
16	Braided	4-32	9164	9064	9064A	40
18	Braided	4-32	9184	9084	9084A	35
18	Braided	7-64	9187	9087	9087A	32
19	Braided	7-64	9197	9097	9097A	30
19	Braided	3-32	9193	9093	9093A	28
20 or 22	Braided	3-32	9120 9122	9020 9022	9020A 9022A	26
19	Plain	3-32	9193 P	9093 P	9093B	20
20 or 22	Plain	3-32	9120 P 9122 P	9020 P 9022 P	9020B 9022B	24

Telephone Cables

These are made to include any number of single conductors or twisted pairs of telephone wires either plain or braided, bunched together or laid up concentrically, with a tape or cotton braid or other fibrous covering over all. They are frequently encased in a lead sheath, or armored. These cables vary greatly in construction and are furnished to buyers' requirements and specifications.

Rubber-covered Iron Telephone Wire—Single Conductor



These conductors are generally No. 12 or No. 14 B. W. G. galvanized iron wire insulated with code thickness of vulcanized rubber, either single or double cotton braid weatherproof saturated and wax polished.

Size B. W. G.	Thickness Rubber Inches	Single Braid		Double Braid	
		List Number	Approximate Weight per 1000 Feet	List Number	Approximate Weight per 1000 Feet
12	$\frac{3}{64}$	1512	100	1512A	140
14	$\frac{3}{64}$	1514	75	1514A	100

When furnished in twisted pairs, one conductor contains a raised tracer thread to distinguish it from the other conductor.

Rubber-covered Wires and Cables

In addition to the above styles of telephone wire, we manufacture the following:

Spider Wire

The accepted interpretation of this term is synonymous with Bridle wire, except that it is used singly instead of in pairs. Braids and finish are the same.

Drop Wire

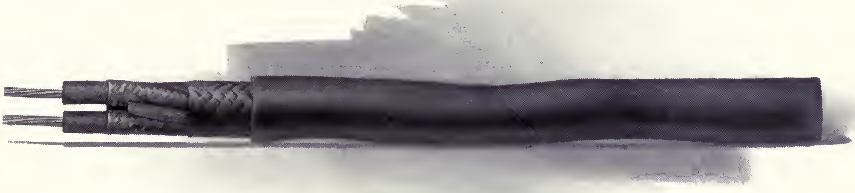
No. 14 B. & S. twisted pair, $\frac{5}{32}$ inch over insulation, with black saturated weatherproof braid, and raised marker in one conductor. Hard drawn copper.

This service involves the drop from the pole terminal to the house bracket. No. 16 B. & S. insulated to $\frac{4}{32}$ inch is extensively used, but on account of the severe service to which this type of wire is put, necessitating great resistance to climatic conditions, No. 14 B. & S. is considered the standard, because of its increased tensile strength.

Jumper Wire

This is often confused with Spider and Bridle wire in outside construction, but by the more general acceptance of the term, it applies to the wire used for cross-connecting service on the main distributing frame. It is usually a No. 20 or No. 22 B. & S. wire insulated to $\frac{3}{32}$ inch with flame-proof braids; if twisted pair, one is red and one white.

Packing House Cord



For Low Potential, 0–600 Volts

Order by List Number

Prices Quoted on Application

Size B. & S.	Thickness of Rubber Inches	List Number	Approximate Weight per 1000 Feet Pounds	Size B. & S.	Thickness of Rubber Inches	List Number	Approximate Weight per 1000 Feet Pounds
10	3-64	4950	142	16	2-64	4956	52
12	3-64	4952	107	18	2-64	4958	41
14	3-64	4954	84	20	2-64	4960	33

Specifications. Each conductor made up of a seven-tinned copper wire strand, insulated with code thickness of vulcanized rubber, covered with a cotton braid, saturated with weatherproof compound. Two such finished conductors twisted into pairs, the interstices of which are filled with jute laterals to make the whole cylindrical, and then braided over all with two heavy cotton braids, saturated with a weatherproof compound, and given a wax polish finish.

Used for incandescent lighting in packing houses and similar places.

Rubber-covered Wires and Cables

Elevator Lighting Cable

This consists of two No. 14 B. & S. rubber insulated and braided conductors, twisted into a cable (with cushioned steel supporting strand if required) and finished with three hard glazed or weatherproof saturated cotton braids.

Brewery Cord

For Low Potential, 0–600 Volts

Size B. & S.	Thickness of Rubber Inches	List Number	Approximate Weight per 1000 Feet Pounds	Size B. & S.	Thickness of Rubber Inches	List Number	Approximate Weight per 1000 Feet Pounds
10	3-64	4930	120	16	2-64	4936	39
12	3-64	4932	89	18	2-64	4938	30
14	3-64	4934	68	20	2-64	4940	23

Specifications. Each conductor made up of a seven-tinned copper wire strand, insulated with code thickness of vulcanized rubber, covered with a cotton braid and saturated with weatherproof compound, wax polish finish. Two such finished conductors are then twisted into pairs, forming a flexible cord.

Border Light Cables

The construction of these cables corresponds exactly with that of Theater or Stage cables (see next page), but consists of more than two conductors.

Deck Cables

Each conductor made up of a seven-tinned copper wire strand insulated with code thickness of vulcanized rubber and covered with a cotton braid. Two such conductors are then twisted into pairs (the interstices of which are filled with jute laterals to make the whole cylindrical), over which is placed a supplementary layer of vulcanized rubber $\frac{1}{32}$ inch thick, then braided over all with one cotton braid saturated with weatherproof compound, wax polish finish.

Size B. & S	List Number	Size B. & S	List Number
10	4960	16	4966
12	4962	18	4968
14	4964	..	. .

Elevator Control Cable

This consists of any number of stranded copper conductors insulated with vulcanized rubber, braided, all stranded into a cable and covered over all with three strong cotton braids saturated with weatherproof compound, wax polish finish.

Steel supporting strands can be included if desired.

Theater or Stage Cables

Consists of two extra flexible strands of tinned copper wires, each strand insulated with code thickness of vulcanized rubber, protected with a cotton braid saturated with weatherproof compound.

Two such finished conductors are then twisted into pairs, the interstices of which are filled with jute laterals to make the whole cylindrical, and over which is then placed two heavy cotton braids, saturated with a weatherproof compound, wax polish finish.

Size, B. & S.	Number of Wires in Strand	List Number	Size, B. & S.	Number of Wires in Strand	List Number
1	259	4971	8	49	4978
2	210	4972	10	31	4980
3	151	4973	12	21	4982
4	133	4974	14	14	4984
6	49	4976	..	..	..

Crown Rubber Insulated Wires and Cables

For Incandescent Lighting, Telegraph and Telephone Service, Street Railway Feeders and Power Transmission Lines. Recommended Specially for Office Buildings and Municipal Wiring

A High Grade Rubber Insulation for National Electrical Code Standard

Crown wire has an insulation which has made a record for long life and for high insulating qualities. The thickness of rubber placed on all code wires and cables provides a wide margin of safety and gives a high grade insulation for all voltages up to 3500, and for arc light circuits of 7000 volts or less.

The conductors are made of tinned annealed copper, of highest conductivity. Covered with code thickness of rubber, protected with one or two closely woven strong and elastic cotton braids, or with tape and braid, saturated in a weatherproof preservative compound and smoothly finished. Purple distinguishing tracer thread embedded in rubber lengthwise of wire and under braid.

Crown Wires

Solid Tinned Copper Conductor

National Electrical Code Standard

For Low Potential—0-600 Volts

Order by List Number

Size B. & S.	Diameter Bare Wire Inches	Thickness of Rubber Inches	Approximate Diameter Over Single Braid Inches	Approximate Diameter Over Double Braid Inches	List Number Single Braid Black Finish	List Number Single Braid White Finish	List Number Double Braid Black Finish	Standard Packages Approx. Quantities, Feet	Shipped on Reel Number
0000	.460	5-64	44-64	47-64	400C	440C	425C	1000	1002
000	.409	5-64	40-64	43-64	400B	440B	425B	1000	335
00	.365	5-64	37-64	40-64	400A	440A	425A	1000	335
0	.325	5-64	34-64	37-64	400	440	425	1000	335
1	.289	5-64	32-64	35-64	401	441	426	1000	334
2	.257	4-64	28-64	31-64	402	442	427	1000	334
3	.229	4-64	26-64	29-64	403	443	428	1000	334
4	.204	4-64	24-64	27-64	404	444	429	1000	1004
5	.182	4-64	23-64	26-64	405	445	430	1000	1004
6	.162	4-64	21-64	24-64	406	446	431	500	Coils
8	.128	3-64	17-64	20-64	408	448	432	500	Coils
10	.102	3-64	15-64	18-64	410	450	433	500	Coils
12	.081	3-64	14-64	17-64	412	452	434	500	Coils
14	.064	3-64	13-64	16-64	414	454	435	500	Coils
16	.051	2-64	10-64	13-64	416	456	436	500	Coils
18	.040	2-64	9-64	12-64	418	458	437	500	Coils

Specifications. Solid tinned annealed copper wire of highest conductivity, insulated with code thickness of high grade vulcanized rubber, protected with one or two smooth, closely woven, strong and elastic cotton braids, saturated in black weatherproof compound for outside, or white for inside use; special finish for unlined conduit work.

Regarding reels, see page 50.

For Medium Potentials—600-3500 Volts

Prices Quoted on Application

Size B. & S.	Area Circular Mils	Thickness of Rubber Inches	Approximate Diameter Over Single Braid Inches	Approximate Diameter Over Double Braid Inches	List Number Single Braid Black Finish	List Number Single Braid White Finish	List Number Double Braid Black Finish	Standard Packages Approx. Quantities, Feet	Shipped on Reel Number
0000	211,600	3-32	46-64	49-64	480C	670C	540C	1000	1002
000	167,772	3-32	43-64	46-64	480B	670B	540B	1000	335
00	133,079	3-32	39-64	42-64	480A	670A	540A	1000	335
0	105,625	3-32	37-64	40-64	480	670	540	1000	335
1	83,694	3-32	34-64	37-64	481	671	541	1000	334
2	66,358	3-32	32-64	35-64	482	672	542	1000	334
3	52,624	3-32	30-64	33-64	483	673	543	1000	334
4	41,738	3-32	28-64	31-64	484	674	544	1000	1004
5	33,088	3-32	27-64	30-64	485	675	545	1000	1004
6	26,244	3-32	26-64	29-64	486	676	546	1000	1004
8	16,512	3-32	23-64	26-64	488	678	548	500	Coils
10	10,384	3-32	22-64	25-64	490	680	550	500	Coils
12	6,529	3-32	20-64	23-64	492	682	552	500	Coils
14	4,109	3-32	19-64	22-64	494	684	554	500	Coils

Specifications. Solid tinned annealed copper wire of highest conductivity, insulated with code thickness of high grade vulcanized rubber for 3500 volts or less, protected with one or two smooth, closely woven, strong and elastic cotton braids, saturated in black weatherproof compound for outside, or white for inside use; special finish for unlined conduit work.

No. 14 B. & S. and larger, inspected and tested by the Wire Inspection Bureau.

Crown Cables

Stranded Tinned Copper Conductor

National Electrical Code Standard

For Low Potential, 0–600 Volts

Order by List Number

Size B. & S.	Number and Size of Wires in Strand Inches	Thickness of Rubber Inches	Approximate Diameter Over		List Number			Standard Packages Approx. Quantities, Feet	Shipped on Reel Number
			Single Braid Inches	Double Braid Inches	Single Braid Black Finish	Single Braid White Finish	Double Braid Black Finish		
0000	37x.0756	5-64	49-64	52-64	500	100 C	525	1000	1002
000	37x.0673	5-64	45-64	48-64	501	100 B	526	1000	335
00	37x.0599	5-64	41-64	44-64	502	100A	527	1000	335
0	19x.0746	5-64	38-64	41-64	503	100	528	1000	335
1	19x.0663	5-64	35-64	38-64	504	101	529	1000	334
2	19x.0592	4-64	30-64	33-64	505	102	530	1000	334
3	19x.0526	4-64	28-64	31-64	506	103	531	1000	334
4	7x.0772	4-64	26-64	29-64	507	104	532	1000	1004
6	7x.0612	4-64	23-64	26-64	508	106	533	1000	1004
8	7x.0485	3-64	18-64	21-64	509	108	534	500	Coils
10	7x.0385	3-64	16-64	19-64	510	110	535	500	Coils
12	7x.0306	3-64	15-64	18-64	512	112	536	500	Coils
14	7x.0243	3-64	14-64	17-64	514	114	537	500	Coils

Specifications. Tinned annealed copper strand of highest conductivity, insulated with code thickness of high grade vulcanized rubber, protected with one or two smooth closely woven cotton braids saturated in black weatherproof compound for outside and white for inside use; special finish for unlined conduit work. Inspected and tested by the Wire Inspection Bureau.

Regarding reels, see page 50.

For Medium Potential, 600–3,500 Volts

Prices Quoted on Application

Size B. & S.	Area Circular Mils	Thickness of Rubber Inches	Approximate Diameter Over		List Number			Standard Packages Approx. Quantities, Feet	Shipped on Reel Number
			Single Braid Inches	Double Braid Inches	Single Braid Black Finish	Single Braid White Finish	Double Braid Black Finish		
0000	211,600	3-32	51-64	54-64	120 C	160 C	140 C	1000	1002
000	167.772	3-32	47-64	50-64	120 B	160 B	140 B	1000	335
00	133,079	3-32	43-64	46-64	120A	160A	140A	1000	335
0	105,625	3-32	40-64	43-64	120	160	140	1000	335
1	83,694	3-32	37-64	40-64	121	161	141	1000	334
2	66,358	3-32	34-64	37-64	122	162	142	1000	334
3	52,624	3-32	32-64	35-64	123	163	143	1000	334
4	41,738	3-32	30-64	33-64	124	164	144	1000	1004
6	26,244	3-32	27-64	30-64	126	166	146	1000	1004
8	16,512	3-32	24-64	27-64	128	168	148	500	Coils
10	10,384	3-32	22-64	24-64	130	170	150	500	Coils
12	6,529	3-32	21-64	24-64	132	172	152	500	Coils
14	4,109	3-32	20-64	23-64	134	174	154	500	Coils

Specifications. Tinned annealed copper strand of highest conductivity, insulated with code thickness of high grade vulcanized rubber for 3500 volts or less, protected with one or two smooth closely woven cotton braids saturated in black weatherproof compound for outside and white for inside use; special finish for unlined conduit work. Inspected and tested by the Wire Inspection Bureau.

The construction of stranded copper conductors is described on page 34.

Crown Flexible Cables

Flexible Tinned Copper Conductor—Black Finish

National Electrical Code Standard

For Low Potential, 0–600 Volts

Order by List Number

Size B. & S.	Number and Diam. of Wires in Strand Inches	Thickness of Rubber Inches	Approximate Diameter over Single Braid Inches	Approximate Diameter over Double Braid Inches	List Number Single Braid	List Number Double Braid	Standard Packages Approx. Quantities, Feet	Shipped on Reels Number
1	259 x .018	5–64	37–64	40–64	601	625	1000	334
2	210 x .018	4–64	33–64	36–64	602	626	1000	334
3	151 x .018	4–64	30–64	33–64	603	627	1000	1004
4	133 x .018	4–64	27–64	30–64	604	628	1000	1004
6	82 x .018	4–64	23–64	26–64	606	629	1000	1004
6	49 x .023	4–64	23–64	26–64	606 A	629 A	1000	1004
8	49 x .0184	3–64	19–64	22–64	608	630	500	Coils
9	40 x .018	3–64	18–64	21–64	609	631	500	Coils
10	19 x .0234	3–64	17–64	20–64	610	632	500	Coils
12	19 x .0185	3–64	15–64	18–64	612	633	500	Coils
14	19 x .0147	3–64	14–64	17–64	614	634	500	Coils

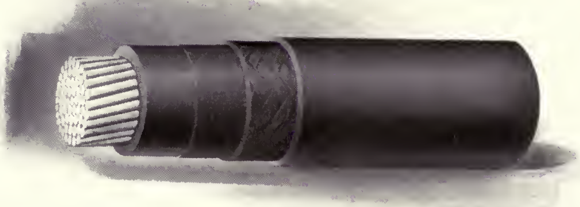
Specifications. Tinned annealed extra flexible strand of highest conductivity, insulated with code thickness of high grade vulcanized rubber, protected with one or two smooth closely woven cotton braids, saturated in black weatherproof compound and smoothly finished.

Inspected and tested by the Wire Inspection Bureau.

The above are for switchboard, brush holder and similar connections where very flexible cables are required.

Regarding reels, see page 50.

Crown Feeder Cables



Stranded Tinned Copper Conductor—Insulated—Tape and Double Braid—Black Finish

National Electrical Code Standard

For Electric Lighting Mains, Street Railway Feeders and Power Transmission Lines

Prices Quoted on Application

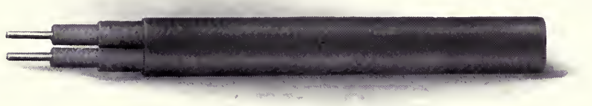
Capacity in Circular Mils	Number and Diam. of Wires in Strand Inches	For 600 Volts Thickness of Rubber Inches	For 600 Volts Approx. Diameter Over Tape and Braid Inches	For 600 Volts List Number Single Braid	For 3500 Volts Thickness of Rubber Inches	For 3500 Volts Approx. Diameter Over Tape and Braid Inches	For 3500 Volts List Number Single Braid	Shipped on Reel Number
250,000	37 x .0822	3–32	56–64	240	3–32	52–64	250A	1013
300,000	37 x .0901	3–32	59–64	241	3–32	55–64	251A	1013
350,000	37 x .0973	3–32	62–64	242	3–32	58–64	252A	1013
400,000	37 x .1040	3–32	65–64	243	3–32	61–64	253A	1013
450,000	37 x .1103	3–32	68–64	244	3–32	64–64	254A	1020
500,000	61 x .0905	3–32	72–64	245	3–32	68–64	255A	1020
600,000	61 x .0992	7–64	79–64	246	4–32	81–64	256	1020
750,000	61 x .1109	7–64	86–64	247	4–32	88–64	257	1020
1,000,000	61 x .1280	7–64	96–64	248	4–32	98–64	258	1021
1,250,000	91 x .1172	8–64	107–64	248A	4–32	109–64	259	1021
1,500,000	91 x .1284	8–64	115–64	249	4–32	115-64	260	1015
2,000,000	127 x .1255	8–64	129–64	249A	4–32	129–64	261	. .

Specifications. Tinned annealed copper strands of highest conductivity, insulated with code thickness of high grade vulcanized rubber, for required voltage, protected with tape and with one or two smooth closely woven cotton braids, as required, saturated in black weatherproof compound.

Shipped on reels containing approximately 1000-foot lengths.

We are prepared to manufacture wires and cables of any style and to any specification.

Crown Duplex Wires and Cables



Solid Tinned Copper Conductors

National Electrical Code Standard

Two Conductors Laid Parallel with Braid Over All

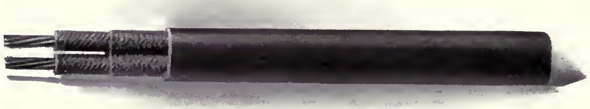
Order by List Number For Low Potential, 0-600 Volts

Size B. & S.	Thickness of Rubber Inches	Approximate Diameters Over Single Braid		List Number		Shipped on Reel Number
		Solid, Inches	Strand, Inches	Solid	Strand	
0000	5-64	48-64 x 91-64	52-64 x 99-64	1260C	180C	1020
000	5-64	44-64 x 82-64	48-64 x 92-64	1260B	180B	1013
00	5-64	41-64 x 77-64	44-64 x 83-64	1260A	180A	1013
0	5-64	38-64 x 71-64	41-64 x 78-64	1260	180	1013
1	5-64	35-64 x 66-64	38-64 x 72-64	1261	181	1002
2	4-64	31-64 x 58-64	34-64 x 63-64	1262	182	1002
3	4-64	29-64 x 54-64	31-64 x 58-64	1263	183	1002
4	4-64	28-64 x 51-64	30-64 x 54-64	1264	184	335
5	4-64	26-64 x 48-64	27-64 x 50-64	1265	185	335
6	4-64	25-64 x 45-64	26-64 x 48-64	1266	186	335
8	3-64	21-64 x 31-64	22-64 x 39-64	1268	188	1004
10	3-64	19-64 x 33-64	20-64 x 35-64	1270	190	Coils
12	3-64	17-64 x 31-64	18-64 x 32-64	1272	192	Coils
14	3-64	16-64 x 28-64	17-64 x 29-64	1274	194	Coils
16	2-64	13-64 x 22-64	. . . . .	1276	. .	Coils
18	2-64	12-64 x 21-64	. . . . .	1278	. .	Coils

Specifications. Tinned annealed copper wires or strands of highest conductivity, each conductor insulated with code thickness of high grade vulcanized rubber, protected by saturated braid; two such finished conductors laid parallel and covered with a heavy cotton braid over all, saturated in black weatherproof compound. Special finish for conduit work. The underwriters' rules permit the use of the above in sizes No. 14 and larger. No. 6 and larger shipped on reels containing approximately 1000-foot lengths; smaller sizes shipped in coils containing approximately 500-foot lengths.

Regarding reels, see page 50.

Crown Duplex Wires and Cables



Stranded Tinned Copper Conductors, Insulated and Braided—Black Finish

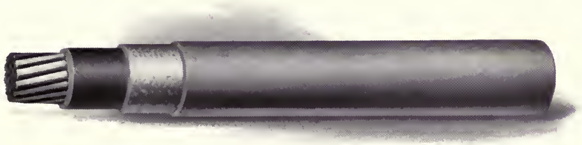
National Electrical Code Standard

Two Conductors Laid Parallel with Braid Over All. For Medium Potential, 600-3,500 Volts Prices Quoted on Application

Size B. & S.	Thickness of Rubber Inches	Approximate Diameters Over Single Braid		List Number		Shipped on Reel Number
		Solid, Inches	Strand, Inches	Solid	Strand	
0000	3-32	50-64 x 94-64	54-64 x 104-64	650 C	200 C	1020
000	3-32	46-64 x 88-64	50-64 x 96-64	650 B	200 B	1013
00	3-32	43-64 x 81-64	46-64 x 89-64	650 A	200 A	1013
0	3-32	40-64 x 76-64	43-64 x 82-64	650	200	1013
1	3-32	38-64 x 70-64	40-64 x 77-64	651	201	1002
2	3-32	36-64 x 66-64	37-64 x 71-64	652	202	1002
3	3-32	33-64 x 62-64	35-64 x 67-64	653	203	1002
4	3-32	32-64 x 59-64	33-64 x 63-64	654	204	335
5	3-32	30-64 x 56-64	32-64 x 59-64	655	205	335
6	3-32	29-64 x 54-64	30-64 x 56-64	656	206	335
8	3-32	27-64 x 49-64	27-64 x 52-64	658	208	1004
10	3-32	25-64 x 45-64	25-64 x 48-64	660	210	Coils
12	3-32	24-64 x 43-64	24-64 x 44-64	662	212	Coils
14	3-32	23-64 x 41-64	23-64 x 42-64	664	214	Coils

Specifications. Tinned annealed copper wires or strands of highest conductivity, each conductor insulated with code thickness of high grade vulcanized rubber for 3500 volts, protected by saturated braid, two such finished conductors laid parallel, covered with a heavy cotton braid over all, saturated in black weatherproof compound. Special finish for conduit work. Sizes 14 and larger, inspected and tested by Wire Inspection Bureau. The underwriters' rules permit the use of the above in lined and unlined conduits. No. 6 and larger shipped on reels containing approximately 1000-foot lengths. Smaller sizes shipped in coils containing approximately 500-foot lengths.

Crown Fireproof Cables



Stranded Tinned Copper Conductor—Double Braid—White Finish

For High Potential, Exposed Arc Lighting and Station Wiring

Order by List Numbers

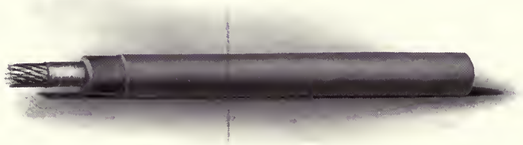
Size B. & S.	Number and Diam. of Wires in Strand Inches	For $\frac{4}{32}$-inch Rubber		For $\frac{5}{32}$-inch Rubber		Shipped on Reel Number
		Approximate Diameter Over Braid Inches	List Number	Approximate Diameter Over Braid Inches	List Number	
0000	37 x .0756	59-64	720C	63-64	730C	1002
000	37 x .0673	55-64	720B	59-64	730B	335
00	37 x .0599	52-64	720A	56-64	730A	335
0	19 x .0746	49-64	720	53-64	730	335
1	19 x .0663	46-64	721	50-64	731	334
2	19 x .0592	42-64	722	47-64	732	334
4	7 x .0772	39-64	724	43-64	734	334
6	7 x .0612	35-64	726	39-64	736	1004
8	7 x .0485	33-64	728	37-64	738	1004

Specifications. Tinned annealed copper strand of highest conductivity, insulated with required thickness of high grade vulcanized rubber, protected with two smooth, closely woven strong heavy cotton braids, each of which is thoroughly saturated in white flame-proof compound, smoothly finished. See note below.

This wire is placed before the public at the suggestion of many superintendents of electric light companies who are using it for wiring their stations. It is fireproof in the sense that the braid will not ignite or carry flame.

Shipped on reel containing approximately 1000-foot lengths.

Car Cables



Stranded Tinned Copper Conductor—Rubber Insulation
Single Braid—Black Finish

For Low Potential—0-600 Volts

Prices Quoted on Application

Size B. & S.	Number and Diam. of Wires in Strand Inches	Thickness of Rubber Inches	Approximate Diameter Over Braid Inches	List Number		Standard Packages Approximate Quantities Feet	Shipped on Reel Number
				Crown Insulation	Globe Insulation		
2	19 x .0592	4-64	31-64	705	1322	1000	334
3	19 x .0526	4-64	29-64	706	1323	1000	334
4	49 x .0292	4-64	29-64	707A	1324	1000	1004
4	7 x .0772	4-64	27-64	707	1325	1000	1004
6	49 x .023	4-64	25-64	708A	1326	1000	1004
6	7 x .0612	4-64	24-64	708	1327	1000	1004
8	7 x .0485	3-64	20-64	709	1328	500	Coils
10	7 x .0385	3-64	18-64	710	1330	500	Coils
12	7 x .0306	3-64	17-64	711	1332	500	Coils
14	7 x .0243	3-64	16-64	712	1334	500	Coils

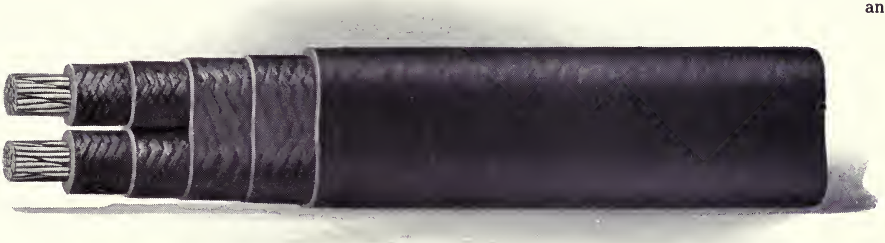
Specifications Car cables consist of tinned annealed copper strand of highest conductivity, over which is placed a wind of fine cotton or paper and a code thickness of vulcanized rubber insulation. This is protected by a braid of closely woven cotton braid, thoroughly saturated with black weatherproof compound and finished smooth.

This cable is used for both power and light circuits in electric cars and motor lead cables. It differs from the other rubber insulated conductors already described, in having a layer of fine cotton or paper wound on the conductor underneath the rubber, which is easily removed and which leaves the conductor clean for jointing.

NOTE—We can furnish *any* style or size of rubber-covered wire, covered with one, two or any number of braids, saturated in fireproof compound, smoothly finished. High voltage cables for interior service, as in switchboard or station work, if protected by heavy braids, thoroughly flame-proofed, give exceptionally good protection where the reduction of fire risk is essential. This fire-resisting covering possesses good mechanical and moisture-proof qualities, and is capable of localizing the effects of burnouts or external combustions. Regarding reels, see page 50.

Rubber-covered Wires and Cables

Mining Machine Cables



Tinned Copper—Duplex Parallel—Flexible Conductors

For Low Potential, 0–600 Volts

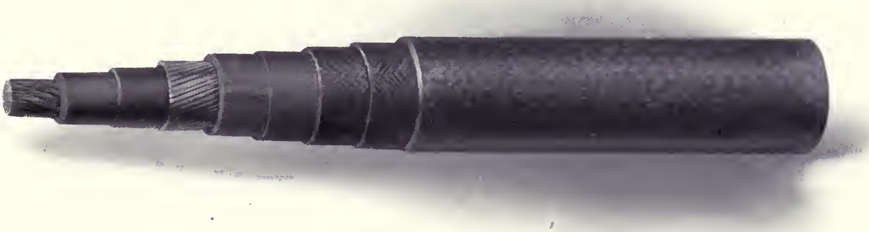
Size B. & S.	Number and Diameter of Wires in Strand, Inches	Thickness of Rubber Inches	Approximate Dimensions of 3-Braid Finished Cable, Inches	Approximate Weight per 1000 Feet 3-Braid, Lbs.	List Number for 3 Outer Braids		Shipped on Reel Number
					Crown Insulation	Globe Insulation	
2	49 x .0369	4–64	1.174 x .700	748	290	1342	1002
3	49 x .0327	4–64	1.081 x .650	597	291	1343	1002
4	49 x .0292	4–64	1.000 x .608	468	292	1344	335
5	49 x .026	4–64	.930 x .565	408	292A	1344A	335
6	49 x .023	4–64	.920 x .545	344	293	1346	335
8	49 x .0184	3–64	.880 x .515	232	294	1348	1004
9	49 x .0163	3–64	.696 x .420	204	294A	1348A	1004
10	49 x .0145	3–64	.659 x .400	177	295	1350	1004

Specifications. Mining machine cables consist of two flexible strands of tinned annealed copper of highest conductivity, each of which is insulated with code thickness of vulcanized rubber and protected with a braid of cotton saturated with weatherproof compound. The two finished cables are then placed side by side and covered with two or three strong cotton braids, thoroughly saturated in weatherproof compound. This construction will withstand the most severe abrasions. While this cable is commonly used in sizes from 2 to 10 B. & S., we are prepared to make other sizes to specifications. Hard spun cotton cord braids will be substituted for the regular cotton braid at a slightly advanced price, when same is required for extra hard usage.

As its name indicates, this cable is especially suited for mining purposes or for any other portable service where the cable will receive rough handling.

Regarding reels, see page 50.

Duplex Concentric Stranded Mining Machine Cables



Duplex Concentric Stranded Mining Machine Cables—Continued

For Low Potential, 0–600 Volts

Size B. & S.	Number of Wires		Thickness of Rubber		List Number	Maximun Outside Diameter over One Braid Inch
	Inner Conductor	Outer Conductor	Inner Conductor	Outer Conductor		
4	49	37	4-64	4-64	1354	.825
6	49	37	4-64	4-64	1356	.760
8	49	37	3-64	3-64	1358	.642

Specifications, *Grade "A."* The inner conductor is made up of tinned annealed copper wires, stranded into a flexible cable and insulated with code thickness of high grade vulcanized rubber. This is taped or braided as required. Over this tape or braid is stranded the outer conductor, consisting of a number of tinned annealed copper wires, equal in area to the central conductor. These wires are insulated with code thickness of high grade vulcanized rubber and protected with braid or with tape and braid of strong cotton thoroughly saturated in weatherproof compound. Hard spun cotton cord braids will be substituted for the regular cotton braid at a slightly advanced price, when same is required for extra hard usage.

Grade "B." Made the same as Grade "A" without the outside belt of rubber.

This concentric mining cable is sometimes used as a substitute for the duplex parallel mining cables. It is not so flexible as the duplex parallel and it offers greater difficulties in making connections to the terminal lugs. On the other hand, under certain conditions, the cylindrical form of conductor has advantages over the duplex parallel oval form.

High Grade 30 Per Cent. and Special Rubber Insulated Wires and Cables

For Station Wiring, Arc Light and Signal Service, Street Railroad Feeders and High Voltage Power Transmission Lines

Rubber-covered wires and cables made to the most exacting specifications; in any size or finish and for all services and voltages. Insulated with rubber compounds containing only the highest grades of Para rubber and other necessary preservative ingredients. The exact composition of the rubber compound used and the thickness of the rubber insulation will in every case be determined by the working voltage and by the nature of the service. The conductors will be furnished solid, stranded or extra flexible as ordered, annealed and heavily tinned.

Rubber-covered Wires and Cables

We Manufacture Wires and Cables to the Following Specifications for 30 Per Cent. Rubber Insulating Compound which have been Accepted by the Leading American Engineers

The compound shall contain not less than 30 per cent. by weight of fine dry Para rubber which has not previously been used in rubber compounds. The composition of the remaining 70 per cent. shall be left to the discretion of the manufacturer.

Chemical

The vulcanized rubber compound shall contain not more than 6 per cent. by weight of Acetone Extract. For this determination, the Acetone extraction shall be carried on for five hours in a Soxhlet extractor, as improved by Dr. C. O. Weber.

Mechanical

The rubber insulation shall be homogeneous in character, shall be placed concentrically about the conductor, and shall have a tensile strength of not less than 800 pounds per square inch.

From any wire on which the wall of insulation does not exceed $\frac{4}{32}$ inch, a sample of vulcanized rubber compound not less than 4 inches in length shall be cut with a sharp knife held tangent to the copper. Marks should be placed on the sample 2 inches apart. The sample shall be stretched until the marks are 6 inches apart and then immediately released; one minute after such release, the marks shall not be over 2⅜ inches apart. The sample shall then be stretched until the marks are 9 inches apart before breaking.

In case the wall of insulation exceeds $\frac{4}{32}$ inch, the return required shall be 2½ inches instead of 2⅜ inches, and the stretch before breaking shall be 8 inches instead of 9 inches.

For the purpose of these tests, care must be used in cutting to obtain a proper sample, and the manufacturer shall not be responsible for results obtained from samples imperfectly cut.

These tests are made at a temperature not less than 50 degrees F.

For high tension service, it is recommended that the above mechanical requirements of the rubber be eliminated.

Electrical

Each and every length of conductor shall comply with the requirements given in the following table. The tests shall be made at the works of the manufacturer when the conductor is covered with vulcanized rubber and before the application of other covering than tape or braid.

Tests shall be made after at least twelve hours' submersion in water and while still immersed. The voltage specified shall be applied for five minutes. The insulation test shall follow the voltage test, shall be made with a battery of not less than 100 nor more than 500 volts, and the reading shall be taken after one minute's electrification. Where tests for acceptance are made by the purchaser on his own premises, such tests shall be made within ten days of receipt of wire or cable by purchaser.

Inspection

The purchaser may send to the works of the manufacturer, a representative who shall be afforded all necessary facilities to make the above specified electrical and mechanical tests, and also to assure himself that the 30 per cent. of the rubber above specified is actually put into the compound, but he shall not be privileged to inquire what ingredients are used to make up the remaining 70 per cent. of the compound.

Rubber-covered Wires and Cables

Specifications—Continued

Voltage Test for Five Minutes

For Thirty Minutes' Test, Take 80 Per Cent. of These Figures

Size	Thickness of Insulation in Inches									
	3/64	2/32	5/64	3/32	7/64	4/32	5/32	6/32	7/32	8/32
1000000 to 550000	. .	. .	. .	. .	6000	8000	12000	16000	19000	22000
500000 to 250000	. .	. .	. .	5000	7000	9000	13000	16000	19000	22000
4/0 to 1	. .	. .	4000	6000	8000	10000	13000	16000	19000	22000
2 to 7	. .	3000	5000	7000	9000	11000	14000	16000	18000	20000
8 to 14	3000	4500	6000	7500	9000	10000	11000	12000	. . .	. . .

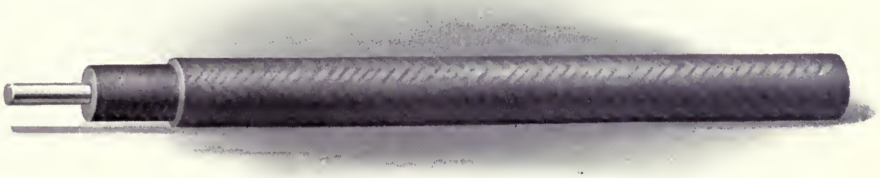
Megohms per Mile—60 Degrees F.

One Minute Electrification

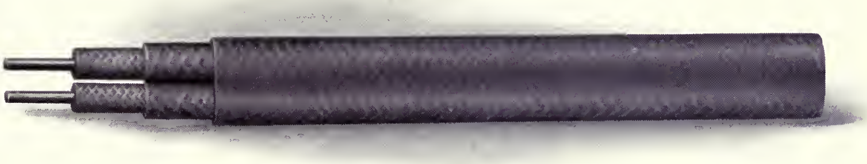
Size	Thickness of Insulation in Inches									
	3/64	2/32	5/64	3/32	7/64	4/32	5/32	6/32	7/32	8/32
1000000 C. M.	. .	. .	. .	. .	300	340	420	490	560	630
900000 C. M.	. .	. .	. .	. .	320	360	440	510	590	660
800000 C. M.	. .	. .	. .	. .	330	380	460	540	610	690
700000 C. M.	. .	. .	. .	. .	350	400	490	570	650	730
600000 C. M.	. .	. .	. .	. .	380	430	520	610	690	770
500000 C. M.	. .	. .	. .	360	410	460	570	660	750	830
400000 C. M.	. .	. .	. .	400	450	510	620	720	820	910
300000 C. M.	. .	. .	. .	450	520	580	700	810	910	1010
250000 C. M.	. .	. .	. .	490	560	630	750	870	980	1090
4/0 Strand	. .	. .	450	530	610	680	820	940	1060	1170
3/0 Strand	. .	. .	500	590	670	740	890	1020	1150	1270
2/0 Strand	. .	. .	560	650	740	820	980	1130	1260	1380
1/0 Strand	. .	. .	600	710	800	890	1060	1210	1350	1470
1 Solid	. .	. .	750	870	970	1080	1270	1440	1600	1740
2 Solid	. .	680	820	950	1070	1170	1380	1560	1720	1870
3 Solid	. .	750	900	1040	1160	1280	1490	1680	1850	2000
4 Solid	. .	820	980	1130	1260	1380	1610	1800	1980	2140
5 Solid	. .	910	1070	1230	1370	1500	1740	1940	2130	2290
6 Solid	. .	990	1160	1330	1480	1610	1860	2070	2260	2430
8 Solid	950	1170	1370	1560	1720	1870	2140	2360	2570	2750
9 Solid	1040	1280	1490	1680	1850	2000	2280	2520	2730	2910
10 Solid	1130	1390	1610	1810	1990	2150	2440	2680	2890	3000
12 Solid	1340	1620	1860	2080	2270	2440	2750	3000	3220	3420
14 Solid	1550	1860	2120	2360	2560	2740	3060	3320	3550	3750

Rubber-covered Wires and Cables

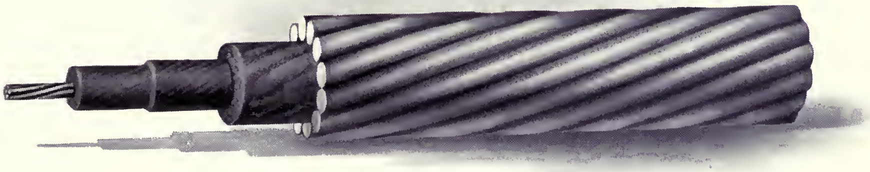
Signal Wires and Cables



Solid Conductor, Insulated and Braided



Duplex Signal Wires, Insulated and Braided



Armored Torpedo Cable

Wires and cables under this head are made to meet, in every respect, the rigid specifications of the Railway Signal Association. They are insulated with 30 per cent. Para rubber or a higher grade, as may be required by the leading railroads of the country. These signal wires and cables may consist of single rubber-covered conductors or of any number of such conductors stranded into a cable. While the construction used by one railroad may differ in some minor respects from that required by another company, in the main, the following extracts from the Railway Signal Association specifications fairly represent standard practice:

Conductors are of soft drawn copper of 98 per cent. conductivity or higher, thoroughly annealed and well tinned, in sizes generally from No. 6 to No. 18 B. & S. inclusive, though other sizes are made to order.

Rubber-covered Wires and Cables

Specifications for Signal Wires and Cables—Continued

Rubber Insulation to consist of vulcanized rubber compound containing not less than 30 per cent. of fine dry Para rubber carefully selected and prepared. The conductors are insulated to the required thickness, depending on whether for aerial or underground use, as per the following tables:

Wires for Aerial Cables			Wires for Underground Cables		
Size B. & S.	Diameter Mils	Thickness of Insulation, Inches	Size B. & S.	Area Cir. Mils	Thickness of Insulation, Inches
6	162	5-64	6	26,250	3-32
8	129	5-64	8	16,509	3-32
9	114	5-64	9	13,090	5-64
10	102	1-16	10	10,380	5-64
12	80.8	1-16	12	6,530	5-64
14	64.1	1-16	14	4,107	5-64
16	50.8	3-64	16	2,583	1-16
18	40.3	3-64	18	1,624	1-16

Taping and Braiding

(a) The rubber insulation is protected with a layer of cotton tape thoroughly filled with a rubber insulating compound, lapped one-half its width and so worked on as to insure a smooth surface.

(b) The outer braid consists of one layer of closely woven cotton braiding at least one thirty-second (1-32) of an inch thick, saturated with a black insulating weatherproof compound which shall have no injurious effect upon the braid at a temperature of 200 degrees Fahrenheit.

Electrical Tests of Rubber Insulation

The circular mils cross-section, the thickness of the rubber insulation (measured at the thinnest point), the minimum insulation resistance in megohms per mile and the dielectric strength for the various sizes of wire conform to the following table:

Size B. & S.	Area in Cir. Mils	Thickness of Insulation, Inches	Insulation Resistance Megohms per mile	Test Voltage Alternating Current
6	26,250	3-32	1300	9,000
8	16,509	3-32	1600	9,000
9	13,090	5-64	1500	7,000
10	10,380	5-64	1600	7,000
12	6,530	5-64	1900	7,000
14	4,107	5-64	2100	7,000
16	2,583	1-16	. . .	4,000
18	1,624	1-16	. . .	4,000

Specifications for Multiple Conductor Aerial Signal Cables, Braided

Conductors furnished in cables must conform to the above table, without tape or braided covering, except tracing wire, which may be taped or braided. The core of the cable must be made up cylindrical in form, with one wire in each layer taped or braided for tracer. Each layer of core must have a spiral lay, each consecutive layer being spiraled in reverse direction from the preceding one. All interstices between conductors in each layer to be filled with jute, each layer of cable to be wrapped with one layer of over-lapping tape. Tape must be of closely woven

Rubber-covered Wires and Cables

cotton, saturated with a permanent moisture-repelling compound which shall not act injuriously on the insulating compound, cotton tape or braid. Over the taped core shall be wrapped a bedding of jute not less than 1-16 inch thick, saturated with tar, one layer of over-lapping tape laid on in reverse order to winding of jute, and a closely woven braid saturated with a permanent weatherproofing compound which is not soluble in water. Cables of more than three and less than seven conductors must be made up with a jute or sisal center.

Underground Multiple Conductor Signal Cables, Braided

Conductors furnished in cables must conform to the table, page 145, each conductor to be taped or braided, tracing wire to be marked in such a manner as to be readily identified. The core of cable must be made up cylindrical in form, with one wire in each layer marked for tracer; each layer of core must have a spiral lay, each consecutive layer being spiraled in reverse direction from the preceding one. Cables of more than three and less than seven conductors must be made up with a jute or sisal center, each layer of cable to be wrapped with one layer of over-lapping tape. Tape must be of closely woven cotton, saturated with a permanent moisture-repelling compound and which shall not act injuriously on the insulation compound, cotton, tape or braid.

The taped core shall be covered with a closely woven braid saturated with a permanent weatherproofing compound which is not soluble in water.

Lead Encased Signal Cables for Aerial Use

Cables to be constructed under specifications for aerial cables, except that the outside wraps of jute and braid are omitted and the cable protected by a lead sheath of not less than the thickness indicated below:

Diameter of Taped Cable	Thickness of Lead, Inches
$\frac{24}{32}$ inch or smaller	1-16
Larger than $\frac{24}{32}$ inch and not exceeding $1\frac{5}{16}$ inches	5-64
Larger than $1\frac{5}{16}$ inches and not exceeding 2 inches	3-32
Larger than 2 inches	1-8

Automobile Ignition Wires and Cables

We are prepared to manufacture automobile wires and cables for both primary and secondary circuits to customers' specifications or samples. These wires are made by the most approved methods and of carefully selected insulating materials. They are designed not only to withstand the severe electrical stresses met with in automobile service, but also the unusual physical conditions that are encountered, such as heat, oil, etc. All of the materials entering into these wires, as well as the finished wires themselves, are carefully tested in our laboratories so that we can guarantee for our automobile wires and cables long life and efficient service.

Rubber-covered Wires and Cables

Approximate Diameters and Weights of Rubber-covered Wires and Cables

Wires and Cables 1/0 and Larger or with 3-32 Insulation or more, have one Tape and one Braid; Others only One Braid

Note—All Dimensions are given in Inches, and Weights in Pounds.

Gauge and Circular Milage of Conductor	No. of Wires in Conductor and Diameter of Each	Diameter of Bare Conductor	N. E. Code Thickness Rubber		Thickness of Rubber									
					3-32		4-32		5-32		6-32		8-32	
			Approx. Diameter Over All	Approx. Weight 1000 Feet	Approx. Diameter Over All	Approx. Weight 1000 Feet	Approx. Diameter Over All	Approx. Weight 1000 Feet	Approx. Diameter Over All	Approx. Weight 1000 Feet	Approx. Diameter Over All	Approx. Weight 1000 Feet	Approx. Diameter Over All	Approx. Weight 1000 Feet
14 B.&S.	1	.0641	.1875	34	.329	73	.393	89	.459	125	.522	169	.667	260
12 B.&S.	1	.0808	.2031	44	.345	87	.409	106	.475	145	.538	186	.683	281
10 B.&S.	1	.1019	.2344	58	.368	102	.430	126	.496	168	.566	209	.704	307
8 B.&S.	1	.1285	.2500	82	.394	127	.459	155	.522	199	.591	244	.730	344
6 B.&S.	1	.1620	.3125	129	.428	169	.493	201	.562	243	.625	291	.764	398
5 B.&S.	1	.1819	.3438	154	.448	196	.513	231	.582	274	.645	322	.784	433
4 B.&S.	1	.2043	.3594	185	.473	230	.535	266	.604	311	.680	366	.806	475
3 B.&S.	1	.2294	.3906	223	.498	272	.566	309	.629	355	.705	408	.831	525
2 B.&S.	1	.2576	.4219	270	.528	322	.596	362	.659	411	.735	466	.861	588
1 B.&S.	1	.2893	.4844	348	.558	383	.626	427	.702	479	.765	537	.891	663
0 B.&S.	1	.3250	.5625	423	.600	463	.675	525	.738	583	.801	644	.927	783
00 B.&S.	1	.3648	.6094	534	.640	557	.735	566	.778	622	.841	749	.967	895
000 B.&S.	1	.4096	.6563	653	.698	679	.760	748	.823	812	.886	883	1.012	1038
0000 B.&S.	1	.4600	.7344	817	.748	840	.810	916	.873	976	.936	1051	1.062	1215
4,109 C. M.	7 x .0243	.0729	.2031	37	.330	73	.402	101	.464	136	.534	178	.661	270
6,529 C. M.	7 x .0306	.0918	.2188	47	.356	88	.421	117	.486	153	.549	195	.689	290
10,384 C. M.	7 x .0385	.1155	.2344	59	.380	107	.445	136	.510	175	.573	218	.717	317
16,512 C. M.	7 x .0485	.1455	.2813	83	.412	135	.474	167	.540	208	.608	243	.746	357
26,244 C. M.	7 x .0612	.1836	.3438	130	.450	177	.515	212	.580	255	.646	303	.784	414
33,088 C. M.	7 x .0687	.2061	.3792	173	.473	205	.540	241	.607	286	.669	338	.807	450
41,738 C. M.	7 x .0772	.2316	.3906	186	.501	239	.563	278	.632	325	.707	378	.832	496
52,624 C. M.	19 x .0526	.2630	.4219	232	.531	291	.598	322	.661	371	.736	426	.861	550
66,358 C. M.	19 x .0592	.2960	.4531	290	.563	350	.630	377	.706	428	.768	486	.893	614
83,694 C. M.	19 x .0663	.3315	.5313	369	.608	413	.670	448	.746	501	.808	563	.933	647
105,625 C. M.	19 x .0746	.3730	.6094	467	.649	496	.724	530	.787	590	.849	650	.974	790
133,079 C. M.	37 x .0599	.4193	.6563	564	.708	595	.770	628	.833	689	.895	755	1.020	901
167,722 C. M.	37 x .0673	.4711	.7344	687	.759	715	.821	754	.884	820	.946	889	1.091	1044
211,600 C. M.	37 x .0746	.5292	.7969	842	.817	880	.879	912	.942	982	1.004	1057	1.149	1221
250,000 C. M.	37 x .0822	.5754	.864	1071	.864	1071	.938	1063	.984	1161	1.051	1311	1.196	1493
300,000 C. M.	37 x .0901	.6307	.922	1250	.922	1250	1.000	1255	1.031	1352	1.129	1501	1.254	1698
350,000 C. M.	37 x .0973	.6811	.973	1431	.973	1431	1.078	1463	1.125	1570	1.180	1699	1.305	1898
400,000 C. M.	37 x .1040	.7280	1.021	1608	1.021	1608	1.125	1651	1.172	1760	1.228	1885	1.353	2098
450,000 C. M.	37 x .1103	.7721	1.065	1791	1.065	1791	1.156	1775	1.219	1963	1.272	2077	1.397	2294
500,000 C. M.	61 x .0905	.8145	1.127	1959	1.127	1959	1.187	1985	1.250	2105	1.314	2258	1.439	2486
600,000 C. M.	61 x .0992	.8928	1.236	2355	. . .	. .	1.265	2328	1.328	2556	1.392	2630	1.517	2864
750,000 C. M.	61 x .1109	.9981	1.341	2881	. . .	. .	1.375	2810	1.438	3046	1.497	3179	1.622	3431
1,000,000 C. M.	61 x .1280	1.1520	1.497	3754	. . .	. .	1.531	3870	1.594	3945	1.653	4082	1.788	4362
1,250,000 C. M.	91 x .1172	1.2892	1.671	4637	. . .	. .	1.671	4637	1.734	4790	1.788	4964	1.913	5264
1,500,000 C. M.	91 x .1284	1.4124	1.793	5460	. . .	. .	1.793	5460	1.859	5705	1.912	5842	2.037	6163
2,000,000 C. M.	127 x .1255	1.6315	2.047	6950	. . .	. .	2.047	6950	2.078	7256	2.130	7586	2.255	7950

Lead Encased Wires and Cables

Page
Multiple Conductor Cables 148
Lead Sheaths 148–158
Rubber Insulated Lead Encased Cables . . 150
Paper Insulated Lead Encased Cables . . . 155
Specifications for Paper Lead Cables . . 157
Varnished Cambric Cables 163
Submarine Cables 164
Installation of Underground Cables . . . 166

Lead Encased Wires and Cables

Electric Light and Power Cables, Lead Encased or Armored

We are extensive makers of lead encased or armored electric light and power cables of all types, aerial, underground and submarine. We are thoroughly equipped to make these to the most rigid specifications, in any quantity, size or length, for any voltage, and finished for any service, single or multiple conductor or concentric laid. Only the very best of materials, selected and prepared with the greatest of care and skill, enter into the construction of these cables. When left to us, we use that particular thickness and arrangement of insulating material, and apply it in such manner as our extensive experience has shown to be best for the purpose for which the cable is to be used.

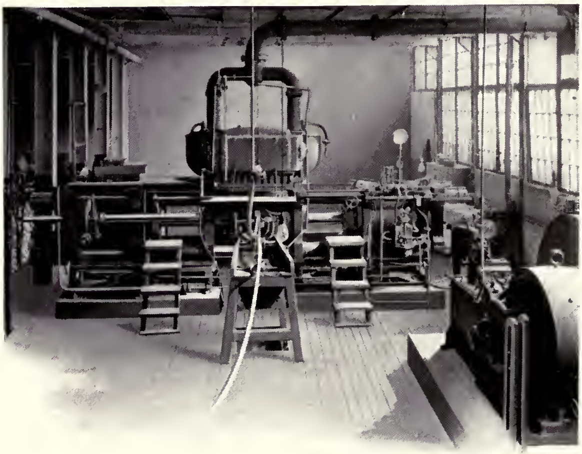
We also contract for the complete installation of underground or submarine cables, or superintend installations as may be required, having a large and well equipped department for this class of work, as fully described on page 166.

Multiple Conductor Cables

In the construction of multiple conductor cables, insulated with rubber, paper or varnished cambric, lateral fillers of jute are generally used to make the conductor solid and cylindrical in form, and to avoid open spaces between insulation and sheath, through which static discharges could take place. The required thickness of insulation can be placed about each separate conductor before it is laid up into the core, or, as is more general, especially with paper and varnished cambric, a portion of the required amount of insulation can be placed in the form of a belt about the assembled conductors. This latter method makes a more even distribution of the insulating material.

When a three-conductor cable is used in a star-connected A. C. circuit with grounded neutral, the thickness of insulation between conductors and ground need be but 0.6 of that between conductors. Separately insulated pressure wires can be incorporated in the core of any form of multiple or single conductor or concentric cable, as may be required. These are used mostly in low tension distributing systems to enable the station attendant to readily determine the voltage at outlying points of the system.

Lead Sheaths



Lead Encased Wires and Cables

In general, cables are sheathed with lead for the purpose of excluding moisture and for protection of the insulation against mechanical injury and other destructive agencies. The purest lead possible to obtain is used for sheathing. It is sometimes required to harden and strengthen the lead sheath by the addition of one, two or three per cent. of tin. It is a question among engineers as to whether much is gained by the addition of tin to the lead. The two metals do not alloy uniformly and in consequence when much tin is used, hard or brittle sections may develop, due to the segregation of one of the metals. The following thicknesses of lead are generally used on our rubber and varnished cambric cables, unless otherwise specified. For paper cables, the sheath should be from one to two sixty-fourths thicker, as specified on page 158.

Outside Diameter of Core (or Inside Diameter of Lead Pipe), Inches	Thickness of Lead Sheath Inches	Outside Diameter of Core (or Inside Diameter of Lead Pipe), Inches	Thickness of Lead Sheath Inches
Up to ¼	$\frac{3}{64}$	1¼ to 1⅝	$\frac{1}{10}$
¼ to ⅝	$\frac{1}{16}$	1⅝ and larger	⅛ to $\frac{9}{64}$
⅝ to 1¼	$\frac{3}{32}$		

This company will not be responsible for the failure of any cable which may be due to openings in the lead sheath caused by electrolysis or other means beyond its control.

Extra Galvanized Steel Armor Wire for Cables

Armor wire is used as a mechanical protection either to the sheath, or as in case of rubber or varnished cambric cables, it is sometimes used to protect the insulation without the sheath. In places where severe vibration would crystallize and break the sheathing, it is customary to use armor wire as a substitute for the sheathing.

Heavily galvanized and pliable medium strength steel is used for armor wire. The particular size of wire and the number of wires best to use, the length and angle of lay, will in every case depend upon conditions of service and installation, matters that are determined by experience. See page 81.

One, two or three layers of jute heavily saturated in petroleum compounds are usually placed over the sheathing or the armor to lessen electrolytic action of stray earth currents and to prevent corrosion from acids.

Inquiries

We make such a great variety of electric light and power cables, they are made in so many different sizes and with so many different thicknesses of insulation, and finished in so many different ways that it would be impracticable to attempt to tabulate them all. Hence only a few of the more common sizes will be listed. This class of our product is making an enviable record, and is well and favorably known in all parts of the country.

We solicit inquiries containing full information.

In making inquiries for special cables please state:

(*a*) Quantity and size of conductor, and construction of the conductor, solid or stranded.

(*b*) If it is to be a multiple conductor cable, give the number and arrangement of conductors desired.

Lead Encased Wires and Cables

(*c*) Kind of insulation, whether rubber, paper, or varnished cambric.

(*d*) Thickness of insulation about each conductor, and of supplementary insulation.

(*e*) Finish of cable, whether braided, plain lead sheath, lead and jute, armor, armor and jute, etc.

(*f*) Kind of current to be transmitted, whether D. C. or A. C., and amount of current.

(*g*) The normal working voltage of the circuit, and if three-conductor A. C., whether connected in Y or △. Also full requirements regarding the test pressure.

(*h*) Purpose for which the cable is intended, whether aerial, underground, submarine, station wiring, arc light, etc.

(*i*) Number and location of pressure wires, if any.

Rubber Insulated, Lead-covered Cables

We make a specialty of heavy rubber cables, lead sheathed, armored, or lead-encased and armored, for all services and voltages, and finished in any style. These are made to meet the most exacting requirements, such as those specified for government and for railway signal service, underground, submarine, or aerial. While taped and braided rubber wires and cables are used for inside and submarine service with entire satisfaction without any lead sheathing, experience has demonstrated the advisability of enclosing the cable in a sheath whenever it is to be used in conduits for underground work, or where it would be exposed to acids, gases, extreme temperature changes, or other destructive agencies.

The composition and properties of our rubber insulations have already been described on pages 116 to 122. Great care is taken in the preparation of our rubber compounds, and in the selection of the rubber and the necessary mineral ingredients. The rubber compound is applied to the conductor in layers under great pressure, thus insuring the centralization of the conductor, and also preventing the formation of air holes in the body of the dielectric. Any number of conductors thus insulated can be stranded into a core or cable, the interstices between the conductors usually being rounded out with jute fillers. In this condition, the cable is ready for the application of the tape and lead sheath, or as sometimes required, a supplementary belt of rubber insulation, and then the tape and sheath or other protection as shown below.

All copper conductors are annealed thoroughly and heavily and evenly tinned, and have a guaranteed conductivity of 98 per cent. or better.

Rubber insulated cables may be finished in any one of the following ways, as may be specified:

Taped and leaded.
Taped, leaded and braided, weatherproof, soapstone or flameproof finish.
Taped, leaded and juted.
Taped, leaded, juted and armored.
Taped, leaded, juted, armored and juted.
Taped, juted and armored.
Taped, juted, armored and juted.

A tracer thread is always laid underneath the tape.

Cables may be taped and braided instead of taped, and in each case one, two or three reverse layers of jute can be used. Other combinations are sometimes required which can be made as specified.

Lead Encased Wires and Cables

Crown Lead Encased Cables

Solid or Stranded Tinned Copper Conductors—Rubber Insulated—Taped and Lead Encased

Order by List Number

Prices Quoted on Application

Size B. & S.	Number of Wires in Conductor	Thickness of Rubber Inches	Thickness of Lead Inches	List Number	Approx Diameter Outside of Lead Inches	Approx. Weight per 1000 Feet Pounds
0000	37	5-64	4-64	770 C	54-64	1542
000	37	5-64	4-64	770 B	50-64	1339
00	37	5-64	4-64	770 A	48-64	1196
0	19	5-64	4-64	770	44-64	1041
1	1	5-64	4-64	771	38-64	875
2	1	4-64	4-64	772	34-64	715
4	1	4-64	3-64	774	29-64	477
6	1	4-64	3-64	776	26-64	391
8	1	3-64	3-64	778	22-64	298
10	1	3-64	3-64	780	21-64	256
12	1	3-64	2-64	782	18-64	156
14	1	3-64	2-64	784	16-64	138
0000	37	4-32	5-64	790 C	62-64	1973
000	37	4-32	5-64	790 B	58-64	1729
00	37	4-32	5-64	790 A	55-64	1574
0	19	4-32	5-64	790	52-64	1422
1	1	4-32	4-64	791	45-64	1004
2	1	4-32	4-64	792	42-64	909
4	1	4-32	4-64	794	39-64	773
6	1	4-32	4-64	796	36-64	686
8	1	4-32	4-64	798	34-64	596

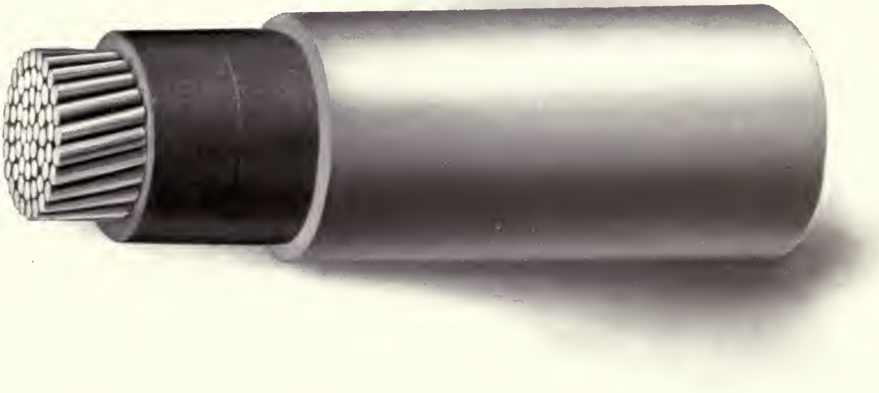
Size B. & S.	Number of Wires in Conductor	Thickness of Rubber Inches	Thickness of Lead Inches	List Number	Approx. Diameter Outside of Lead Inches	Approx. Weight per 1000 Feet Pounds
0000	37	5-32	6-64	755	68-64	2355
000	37	5-32	6-64	756	64-64	2116
00	37	5-32	6-64	757	62-64	1922
0	19	5-32	6-64	758	58-64	1751
1	1	5-32	5-64	759	51-64	1295
2	1	5-32	5-64	760	48-64	1192
4	1	5-32	4-64	740	42-64	871
4	1	6-32	5-64	741	49-64	1157
4	1	6-32	3-32	742	51-64	1349
4	1	7-32	5-64	743	53-64	1282
4	1	7-32	3-32	744	55-64	1485
6	1	5-32	4-64	745	40-64	764
6	1	6-32	5-64	746	46-64	1061
6	1	6-32	3-32	747	48-64	1211
6	1	7-32	5-64	748	50-64	1186
6	1	7-32	3-32	749	52-64	1357
8	1	5-32	4-64	750	38-64	722
8	1	6-32	5-64	751	44-64	993
8	1	6-32	3-32	752	46-64	1171
8	1	7-32	5-64	753	48-64	1114
8	1	7-32	3-32	754	50-64	1306

Shipped on reels containing approximately 1000-foot lengths
See page 50 for information concerning reels.

We are prepared to manufacture wires and cables of any style or to any specification.

Lead Encased Wires and Cables

Crown Lead-covered Cables



Stranded Tinned Copper Conductor—Rubber Insulated—Taped and Lead Encased

Order by List Number Prices quoted on Application

Size in Circular Mils	Number of Wires in Stranded Conductor	Approx. Diameter of Stranded Conductor Inches	Thickness of Rubber Inches	Approx. Thickness of Lead Inches	List Number	Approx. Diameter Over Lead Inches	Approx. Weight per 1000 Feet Pounds
250,000	37	.575	3-32	3-32	801	63-64	2,236
300,000	37	.630	3-32	3-32	802	67-64	2,523
350,000	37	.681	3-32	3-32	803	70-64	2,773
400,000	37	.728	3-32	3-32	804	73-64	3,004
450,000	37	.772	3-32	3-32	805	76-64	3,212
500,000	61	.814	3-32	3-32	806	79-64	3,479
250,000	37	.575	5-32	3-32	1075	72-64	2,576
300,000	37	.630	5-32	3-32	1076	74-64	2,809
350,000	37	.681	5-32	3-32	1077	76-64	3,041
400,000	37	.728	5-32	3-32	1078	82-64	3,344
450,000	37	.772	5-32	3-32	1079	84-64	3,568
500,000	61	.814	5-32	3-32	1080	86-64	3,819
500,000	61	.814	5-32	4-32	1081	91-64	4,483
600,000	61	.892	5-32	4-32	1083	96-64	4,983
750,000	61	.998	5-32	4-32	1085	102-64	5,696
1,000,000	61	1.152	5-32	4-32	1087	112-64	6,891
1,250,000	91	1.289	5-32	4-32	1089	120-64	7,940
1,500,000	91	1.413	5-32	4-32	1091	128-64	9,005
2,000,000	127	1.631	5-32	4-32	1093	142-64	11,091

Crown Lead Encased Cables

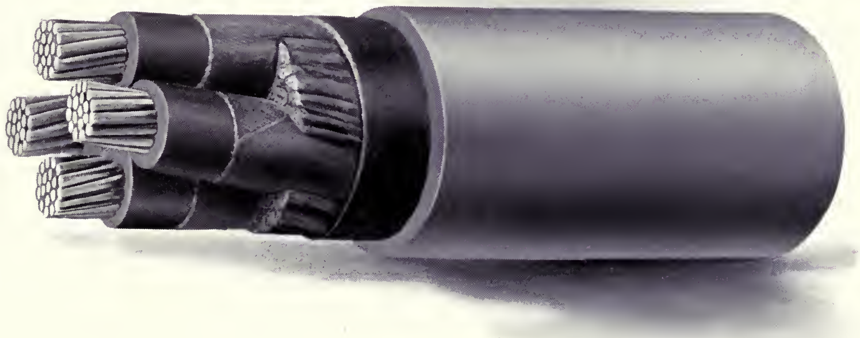
Lead Encased Wires and Cables

Order by List Number

Prices Quoted on Application

Size in Circular Mils	Number Wires in Stranded Conductor	Approx. Diameter of Stranded Conductor Inches	Thickness of Rubber Inches	Approx. Thickness of Lead Inches	Approx. Diameter Over Lead Inches	List Number	Approx. Weight per 1000 Feet Pounds	Approx. Length on a Reel Feet
250,000	37	.575	4-32	3-32	66-64	1050	2379	1000
300,000	37	.630	4-32	3-32	70-64	1051	2711	1000
350.000	37	.681	4-32	3-32	74-64	1052	2980	1000
400.000	37	.728	4-32	3-32	78-64	1053	3190	1000
450,000	37	.772	4-32	3-32	80-64	1054	3357	1000
500,000	61	.814	4-32	3-32	83-64	1055	3668	1000
500 000	61	.814	4-32	4-32	87-64	1056	4317	1000
600.000	61	.892	4-32	3-32	87-64	1057	4078	1000
600,000	61	.892	4-32	4-32	91-64	1058	4755	1000
750.000	61	.998	4-32	3-32	94-64	1059	4745	1000
750,000	61	.998	4-32	4-32	98-64	1060	5470	1000
1.000 000	61	1.152	4-32	3-32	104-64	1061	5938	750
1.000,000	61	1.152	4-32	4-32	108-64	1062	6719	750
1.250.000	91	1.289	4-32	3-32	113-64	1063	6904	750
1,250 000	91	1.289	4-32	4-32	117-64	1064	7780	750
1,500,000	91	1.413	4-32	3-32	120-64	1065	8010	500
1.500,000	91	1.413	4-32	4-32	124-64	1066	8945	500
2.000,000	127	1.631	4-32	3-32	135-64	1067	9890	500
2,000,000	127	1.631	4-32	4-32	139-64	1068	10932	500

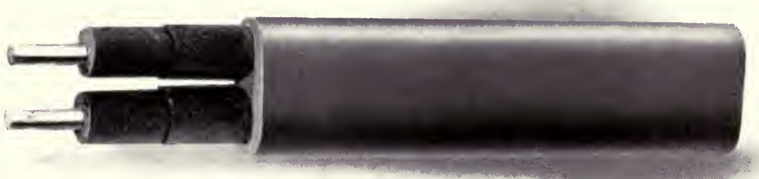
We are prepared to manufacture wires and cables of any style or to any specification.



Four-conductor, Stranded, Rubber, Tape, Jute and Lead

Lead Encased Wires and Cables

Crown Duplex Cables, Lead Encased



Solid or Stranded Tinned Copper Conductors—Rubber Insulated—Taped and Lead Encased

Order by List Number

Prices Quoted on Application

Size B. & S.	Number of Wires in Conductor	Thickness of Rubber Inches	Thickness of Lead Inches	List Number	Approximate Diameter Outside of Lead, Inches	Approx. Weight per 1000 Feet Pounds
0000	37	5-64	4-64	1000 C	54-64 x 104-64	2930
000	37	5-64	4-64	1000 B	50-64 x 96-64	2517
00	37	5-64	4-64	1000 A	47-64 x 90-64	2250
0	19	5-64	4-64	1000	44-64 x 78-64	1957
1	1	5-64	4-64	1001	39-64 x 68-64	1662
2	1	4-64	4-64	1002	38-64 x 62-64	1344
4	1	4-64	3-64	1004	32-64 x 56-64	1082
6	1	4-64	3-64	1006	28-64 x 50-64	758
8	1	3-64	3-64	1008	22-64 x 40-64	598
10	1	3-64	3-64	1010	21-64 x 38-64	513
12	1	3-64	2-64	1012	19-64 x 34-64	330
14	1	3-64	2-64	1014	18-64 x 32-64	282
0000	37	4-32	5-64	1020 C	62-64 x 114-64	3724
000	37	4-32	5-64	1020 B	58-64 x 106-64	3125
00	37	4-32	5-64	1020 A	55-64 x 100-64	2944
0	19	4-32	5-64	1020	52-64 x 94-64	2686
1	1	4-32	4-64	1021	45-64 x 82-64	1800
2	1	4-32	4-64	1022	42-64 x 76-64	1630
4	1	4-32	4-64	1024	39-64 x 70-64	1350
6	1	4-32	4-64	1026	36-64 x 64-64	1208
8	1	4-32	4-64	1028	34-64 x 60-64	1038
0000	37	5-32	6-64	900 C	68-64 x 124-64	4340
000	37	5-32	6-64	900 B	64-64 x 116-64	3874
00	37	5-32	6-64	900 A	62-64 x 112-64	3494
0	19	5-32	6-64	900	58-64 x 104-64	3197
1	1	5-32	5-64	901	51-64 x 92-64	2380
2	1	5-32	5-64	902	48-64 x 86-64	2200
4	1	5-32	5-64	904	45-64 x 80-64	1888
6	1	5-32	4-64	906	40-64 x 72-64	1448
8	1	5-32	4-64	908	39-64 x 70-64	1240
4	..	5-32	4-64	1030	42-64 x 76-64	1610
4	..	6-32	5-64	1031	49-64 x 88-64	2144
4	..	6-32	3-32	1032	51-64 x 90-64	2418
4	..	7-32	5-64	1033	53-64 x 96-64	2309
4	..	7-32	3-32	1034	55-64 x 98-64	2750
6	..	5-32	4-64	1035	40-64 x 72-64	1376
6	..	6-32	5-64	1036	46-64 x 82-64	1912
6	..	6-32	3-32	1037	48-64 x 84-64	2228
6	..	7-32	5-64	1038	50-64 x 90-64	2138
6	..	7-32	3-32	1039	52-64 x 92-64	2438
8	..	5-32	4-64	1040	40-64 x 72-64	1329
8	..	6-32	5-64	1041	46-64 x 82-64	1827
8	..	6-32	3-32	1042	48-64 x 84-64	2154
8	..	7-32	5-64	1043	50-64 x 90-64	2049
8	..	7-32	3-32	1044	52-64 x 92-64	2403

We also carry sizes 4/0 to 10 B. & S., inclusive, with 3/32-inch rubber insulation and proper thickness of lead.

Shipped on reels containing approximately 1000-foot lengths. We are prepared to manufacture wires and cables of any style or to any specification.

Paper Insulated Lead Sheathed Cables

Lead Encased Wires and Cables

For many years past we have manufactured large quantities of paper cables, single and multiple conductor. Our factory equipment is unexcelled for making this class of material to the most exacting specifications.

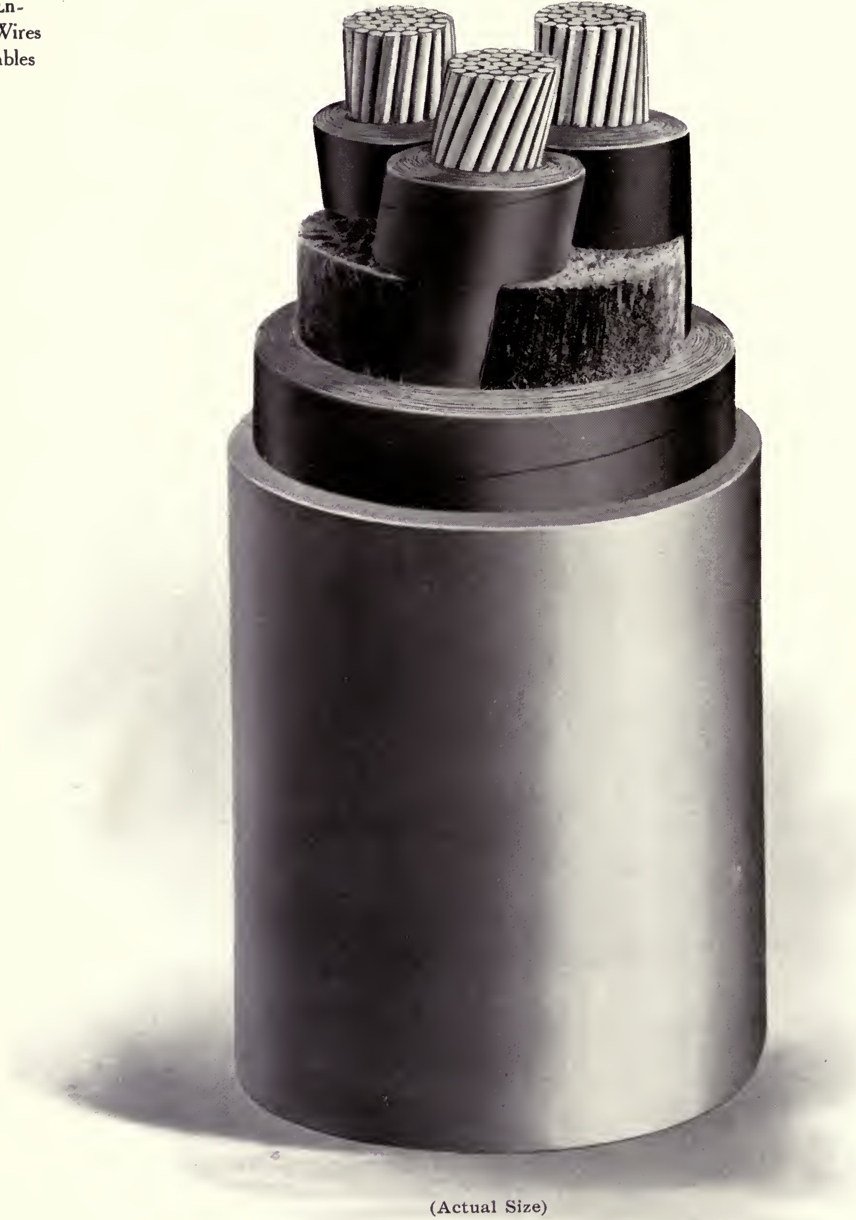
In the construction of paper cables, for electric light and power purposes, narrow and very thin strips of pure Manila paper are wound spirally about the conductor in sufficient number of layers for the required dielectric strength. The material which we use is the very best grade of Manila rope paper, uniform in texture, containing no particles of mineral substances, wood pulp or low grade materials, no pin holes and no trace of alkalies or residual chemicals. The selection of a high grade paper is most essential for permanence and for good dielectric properties.

After the paper covering has been applied to the single conductor, or to the core of conductors in the form of a belt, every trace of air and moisture is removed from the cable by special processes, and while in this condition the core is thoroughly saturated and all interstices completely filled with hot insulating compounds. The cable is then put through a hydraulic press and covered with a closely fitting lead sheathing so as to exclude all air and moisture and to retain the insulating compound. A tracer thread is placed lengthwise of all cables underneath the sheath.

The dielectric value of paper not only depends upon the quality of the paper and the manner of applying it to the conductor, but to a great extent upon the composition of the insulating compound. Increasing the fluidity of the compound within certain limits will improve the puncture test and increase the flexibility of the cable, but will reduce the megohm test, and vice versa. A dense thick compound will result in a very stiff cable, but one having a higher insulation resistance. The insulation of such a cable would be very liable to crack or break if bent at a low temperature, and this would lead to burn-outs.

Paper cables are generally cheaper and have a lower electro-static capacity than rubber or varnished cambric cables. The insulation is strong and uniform in quality, and except when frozen solid, is quite flexible. Paper cables can be worked safely at a higher temperature than can other kinds, and experience has demonstrated that their useful life is practically determined by the integrity of the sheathing. For this reason the thickness of the lead sheath should in general be greater than for corresponding sizes of rubber or cambric cables, by one or two sixty-fourths of an inch. See page 149. Paper is less liable than rubber to deterioration from excessive electro-static strains. In short, the paper insulated cable when properly constructed and sheathed can be recommended as one of the best for most conditions.

Lead Encased Wires and Cables



(Actual Size)

Three-conductor Paper Insulated Lead Encased Cable

4/0 three-conductor, 37 wires each; diameter of each copper conductor, .53 inch; thickness of paper over each conductor, $\frac{5}{32}$ inch; thickness of supplementary paper, $\frac{6}{32}$ inch; thickness of lead, ⅛ inch; diameter over lead, 2.281 inches.

General Cable Specifications for Paper Insulated Lead-covered Cables for Electric Light, Railway and Power Service

Lead Encased Wires and Cables

Rating of Cable

The rating of a cable shall be understood to be the highest E. W. P. (equivalent working pressure) in volts corresponding to any of the specified conditions of service or test. Such rating shall be determined from the following Rating Table, all unlisted intermediates taking the next higher listed figure.

Working Pressure in Volts	Test at Factory in Volts			Test After Installation by Manufacturer in Volts		
	5 Minutes	30 Minutes	60 Minutes	5 Minutes	30 Minutes	60 Minutes
500	1250	1000	1000	1000	1000	1000
1000	2500	2000	1600	2000	1600	1300
1500	3750	3000	2400	3000	2400	1950
2000	5000	4000	3200	4000	3200	2600
2500	6250	5000	4000	5000	4000	3250
3000	7500	6000	4800	6000	4800	3900
4000	10000	8000	6400	8000	6400	5200
5000	12500	10000	8000	10000	8000	6500
6000	15000	12000	9600	12000	9600	7800
7000	17500	14000	11200	14000	11200	9100
8000	20000	16000	12800	16000	12800	10400
9000	22500	18000	14400	18000	14400	11700
10000	25000	20000	16000	20000	16000	13000
11000	27500	22000	17600	22000	17600	14300
12000	30000	24000	19200	24000	19200	15600
13000	32500	26000	20800	26000	20800	16900
14000	35000	28000	22400	28000	22400	18200
15000	37500	30000	24000	30000	24000	19500
16000	40000	32000	25600	32000	25600	20800
17000	42500	34000	27200	34000	27200	22100
18000	45000	36000	28800	36000	28800	23400
19000	47500	38000	30400	38000	30400	24700
20000	50000	40000	32000	40000	32000	26000
21000	52500	42000	33600	42000	33600	27300
22000	55000	44000	35200	44000	35200	28600
23000	57500	46000	36800	46000	36800	29900
24000	60000	48000	38400	48000	38400	31200
25000	62500	50000	40000	50000	40000	32500
26000	65000	52000	41600	52000	41600	33800
27000	67500	54000	43200	54000	43200	35100
28000	70000	56000	44800	56000	44800	36400
29000	72500	58000	46400	58000	46400	37700
30000	75000	60000	48000	60000	48000	39000
Factors	2.5	2.0	1.6	2.0	1.6	1.3

For street railway service (nominal 500-volt D. C.), the E. W. P. shall be 2500 volts for all cables to be operated with a maximum regular working voltage not exceeding seven hundred and fifty (750) volts D. C. and a maximum momentary pressure (thirty (30) seconds or less) not exceeding fifteen hundred (1500) volts D. C.

Lead Encased Wires and Cables

Conductors

Each conductor shall consist of soft drawn copper wires having at least ninety-eight (98) per cent. conductivity based upon Matthiessen's standard (as printed in the supplement to the "Transactions" A. I. E. E., October, 1903), concentrically stranded together and having an aggregate cross-sectional area when measured at right angle to the axes of the individual wires at least equal to that corresponding to the specified size.

Insulation

The insulation shall consist of paper applied helically and evenly to the conductor, and shall be capable of withstanding the test and service conditions corresponding to the highest E. W. P. as determined from the Rating Table set forth on page 157. In the case of cables consisting of more than one (1) conductor (except concentric cables and figure eight (8) or flat form of duplex cables) the separately insulated conductors shall be twisted together with a suitable lay, and the interstices rounded out with jute before the belt insulation is applied. The minimum insulation thickness or thicknesses shall in no case be less than ninety (90) per cent. of the agreed average thickness or thicknesses. All of the insulation shall be thoroughly saturated with an insulating compound.

Sheath

The sheath shall have an average thickness of approximately that indicated in the tabulation next following, and the minimum thickness shall in no place be less than ninety (90) per cent. of the required average thickness.

Diameter of Core in Mils	Corresponding Thickness of Sheath in Inches	Diameter of Core in Mils	Corresponding Thickness of Sheath in Inches
0– 299	5-64	1250–1999	1-8
300– 699	3-32	2000–2699	9-64
700–1249	7-64	2700–over	5-32

The sheath shall consist of commercially pure lead for all cables having a core diameter (i. e., internal diameter of the sheath) less than two inches (2000 mils); for cables having a core diameter equal to two (2) inches or more, the sheath shall consist of an alloy of lead and tin containing not less than ninety-eight (98) per cent. of commercially pure lead and not less than one (1) per cent. of commercially pure tin.

Factory Tests

The manufacturer shall, when so stipulated in the order, notify the company in writing when the cables are ready for test, so that proper tests may be made at the works of the manufacturer by the duly accredited representative of the company. Free access to the testing department shall be given to said representative at all times while cables are being tested hereunder, and the requisite facilities and apparatus for the tests described in these specifications shall be supplied by the manufacturer without extra charge. In case the representative appointed by the company to make factory tests is not wholly and permanently in the employ of the company, said appointment shall be subject to the approval of the manufacturer.

Dielectric Strength: Each length of cable shall withstand a test at factory of a voltage corresponding to the rating (highest E. W. P.) of the cable as detemined from the Rating Table set forth on page 157. Unless otherwise specified by the company at or prior to time of test, the latter shall be the listed five (5) minute

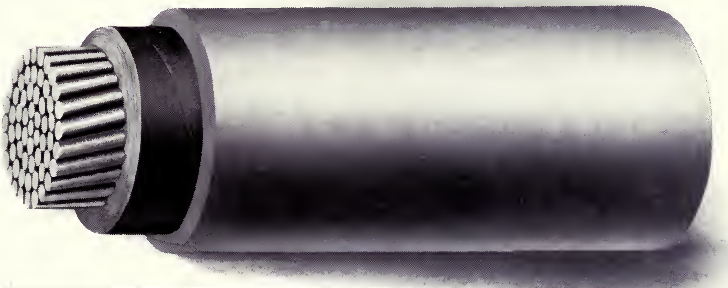
Lead Encased Wires and Cables

factory test set forth in said Rating Table. The conditions and conduct of test shall conform to the recommendations of sections 227 to 259, both inclusive, of the Standardization Rules of the American Institute of Electrical Engineers, as adopted June 21, 1907.

INSULATION RESISTANCE: The insulation resistance shall be determined on each length of cable and shall not be less than fifty (50) megohms per mile when measured at, or corrected to, 60 degrees Fahrenheit. This test shall be made subsequent to the test for dielectric strength, at the end of one minute electrification.

TESTING APPARATUS AND METHODS: Any disagreement as to the accuracy of testing apparatus or methods not specifically covered by this specification, shall be referred to the Bureau of Standards, Washington, D. C.

Paper-insulated and Lead-covered Cables



Size B. & S.	Number and Diam. of Wires in Strand Inches	Thickness of Paper Insulation Inches	Approx. Outside Diameter Inches	Thickness of Lead Inches	List Number	Approx. Weight per 1000 Feet Pounds
0000	37 x .0756	3-32	.937	7-64	1800	2161
000	37 x .0673	3-32	.879	7-64	1801	1919
00	37 x .0599	3-32	.796	3-32	1802	1518
0	19 x .0746	3-32	.750	3-32	1803	1357
1	19 x .0663	3-32	.708	3-32	1804	1221
2	19 x .0592	3-32	.641	5-64	1805	947
3	19 x .0526	3-32	.608	5-64	1806	858
4	7 x .0772	3-32	.577	5-64	1807	783
5	7 x .0687	3-32	.551	5-64	1808	722
6	7 x .0612	3-32	.498	1-16	1809	547
8	7 x .0485	3-32	.460	1-16	1810	472
4	Solid	3-32	.550	5-64	1811	742
5	Solid	3-32	.527	5-64	1812	685
6	Solid	3-32	.476	1-16	1813	518
8	Solid	3-32	.443	1-16	1814	451
0000	37 x .0756	4-32	1.031	1-8	1820	2553
000	37 x .0673	4-32	.941	7-64	1821	2061
00	37 x .0599	4-32	.890	7-64	1822	1851
0	19 x .0746	4-32	.812	3-32	1823	1678
1	19 x .0663	4-32	.771	3-32	1824	1342
2	19 x .0592	4-32	.735	3-32	1825	1222
3	19 x .0526	4-32	.702	3-32	1826	1123
4	7 x .0772	4-32	.639	5-64	1827	882
5	7 x .0687	4-32	.614	5-64	1528	819
6	7 x .0612	4-32	.591	5-64	1829	769
8	7 x .0485	4-32	.553	5-64	1830	681
4	Solid	4-32	.612	5-64	1831	839
5	Solid	4-32	.590	5-64	1832	781
6	Solid	4-32	.570	5-64	1833	733
8	Solid	4-32	.536	5-64	1834	656

Shipped on reels containing approximately 1000-foot lengths.

Lead Encased Wires and Cables

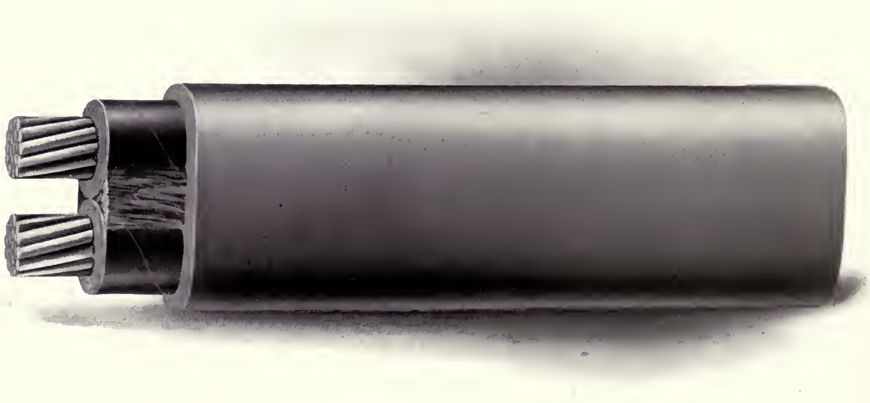
Paper Insulated and Lead Encased Cables

Order by List Number Prices Quoted on Application

Size B. & S.	Number and Diam. of Wires in Strand Inches	Thickness of Paper Insulation Inches	Approximate Outside Diameter Inches	Thickness of Lead Inches	List Number	Approximate Weight per 1000 Feet Pounds
0000	37 x .0756	5-32	1.093	1-8	1840	2,717
000	37 x .0673	5-32	1.035	1-8	1841	2,454
00	37 x .0599	5-32	.952	7-64	1842	1,995
0	19 x .0746	5-32	.906	7-64	1843	1,819
1	19 x .0663	5-32	.864	7-64	1844	1,668
2	19 x .0592	5-32	.798	3-32	1845	1,344
3	19 x .0526	5-32	.765	3-32	1846	1,242
4	7 x .0772	5-32	.733	3-32	1847	1.159
5	7 x .0687	5-32	.708	3-32	1848	1,090
6	7 x .0612	5-32	.654	5-64	1849	869
8	7 x .0485	5-32	.616	5-64	1850	780
4	Solid	5-32	.706	3-32	1851	1,108
5	Solid	5-32	.652	5-64	1852	882
6	Solid	5-32	.632	5-64	1853	831
8	Solid	5-32	.599	5-64	1854	754
0000	37 x .0756	6-32	1.156	1-8	1860	2,882
000	37 x .0673	6-32	1.098	1-8	1861	2,619
00	37 x .0599	6-32	1.046	1-8	1862	2,390
0	19 x .0746	6-32	.968	7-64	1863	1.980
1	19 x .0663	6-32	.927	7-64	1864	1.808
2	19 x .0592	6-32	.891	7-64	1865	1.677
3	19 x .0526	6-32	.858	7-64	1866	1,566
4	7 x .0772	6-32	.796	3-32	1867	1.279
5	7 x .0687	6-32	.770	3-32	1868	1,208
6	7 x .0612	6-32	.748	3-32	1869	1,148
8	7 x .0485	6-32	.710	3-32	1870	1.047
4	Solid	6-32	.768	3-32	1871	1.226
5	Solid	6-32	.746	3-32	1872	1,160
6	Solid	6-32	.726	3-32	1873	1.104
8	Solid	6-32	.691	3-32	1874	1.017

Shipped on reels containing approximately 1000-foot lengths.

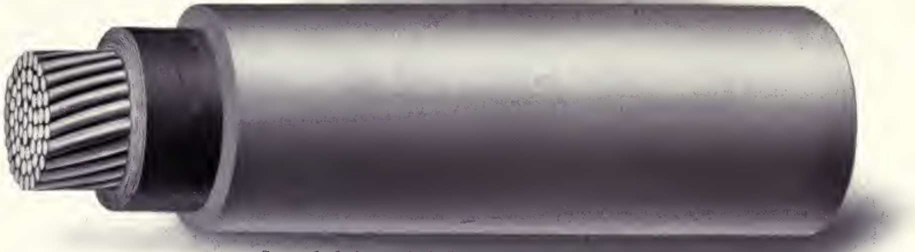
We are prepared to manufacture wires and cables of any style or to any specification. See page 50 for prices of reels.



Duplex Lead Encased Paper Cable

Lead Encased Wires and Cables

Paper Insulated and Lead Encased Cables



Stranded Annealed Copper Conductor

Thickness of Insulation, $\frac{4}{32}$ inch; Lead, ⅛ inch

Order by List Number

Area Circular Mils	Number and Diam. of Wires in Strand Inches	Approximate Outside Diameter Inches	List Number	Approximate Weight per 1000 Feet Pounds	Approximate Length on a Reel Feet
2,000,000	127 x .1255	2.132	31800	10,487	500
1,900,000	127 x .1223	2.090	31802	10,088	500
1,800,000	127 x .1190	2.047	31804	9,685	500
1,750,000	127 x .1174	2.026	31805	9,485	500
1,700,000	127 x .1157	2.004	31806	9,278	500
1,600.000	127 x .1122	1.958	31808	8,860	500
1,500,000	91 x .1284	1.912	31810	8,462	750
1,400,000	91 x .1240	1.864	31812	8,012	750
1,300,000	91 x .1195	1.815	31814	7,630	750
1,250,000	91 x .1172	1.789	31815	7,421	750
1.200,000	91 x .1148	1.762	31816	7,204	750
1,100,000	91 x .1099	1.709	31818	6,779	750
1,000,000	61 x .1280	1.652	31820	6,336	750
900,000	61 x .1215	1.593	31822	5,909	750
800,000	61 x .1145	1.531	31824	5,463	750
750.000	61 x .1109	1.498	31825	5,239	1000
700,000	61 x .1071	1.464	31826	5,004	1000
600,000	61 x .0992	1.393	31828	4,544	1000
500,000	61 x .0905	1.315	31830	4.064	1000
450,000	37 x .1103	1.272	31831	3.818	1000
400,000	37 x .1040	1.228	31832	3,567	1000
350,000	37 x .0973	1.181	31833	3,311	1000
300,000	37 x .0901	1.132	31834	3,047	1000
250.000	37 x .0822	1.075	31835	2.773	1000

Thickness of Insulation, $\frac{5}{32}$ inch; Lead, ⅛ inch

Prices Quoted on Application

Area Circular Mils	Number and Diam. of Wires in Strand Inches	Approximate Outside Diameter Inches	List Number	Approximate Weight per 1000 Feet Pounds	Approximate Length on a Reel Feet
2,000,000	127 x .1255	2.194	32800	10,715	500
1,900.000	127 x .1223	2.153	32802	10,315	500
1,800,000	127 x .1190	2.110	32804	9,909	500
1,750,000	127 x .1174	2.089	32805	9,708	500
1,700,000	127 x .1157	2.066	32806	9,499	500
1,600,000	127 x .1122	2.021	32808	9,078	500
1,500 000	91 x .1284	1.975	32810	8,679	750
1,400,000	91 x .1240	1.927	32812	8,261	750
1,300,000	91 x .1195	1.877	32814	7,841	750
1,250,000	91 x .1172	1.852	32815	7,630	750
1,200,000	91 x .1148	1.825	32816	7,413	750
1,100,000	91 x .1099	1.771	32818	6,984	750
1,000,000	61 x .1280	1.715	32820	6,548	750
900,000	61 x .1215	1.656	32822	6,108	750
800,000	61 x .1145	1.593	32824	5,658	750
750,000	61 x .1109	1.560	32825	5,421	1000
700,000	61 x .1071	1.524	32826	5,200	1000
600,000	61 x .0992	1.455	32828	4,732	1000
500,000	61 x .0905	1.377	32830	4,246	1000
450,000	37 x .1103	1.335	32831	3,998	1000
400,000	37 x .1040	1.290	32832	3,745	1000
350,000	37 x .0973	1.243	32833	3,486	1000
300,000	37 x .0901	1.194	32834	3,220	1000
250,000	37 x .0822	1.138	32835	2,942	1000

Paper Insulated and Lead Encased Cables

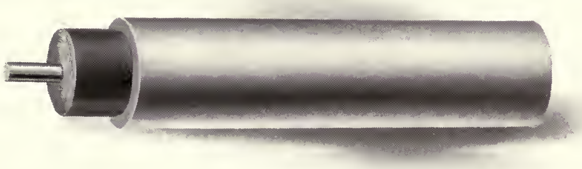
Duplex Stranded Annealed Copper Conductor. Thickness of Insulation, 6-32 Inch; Lead, 1-8 Inch

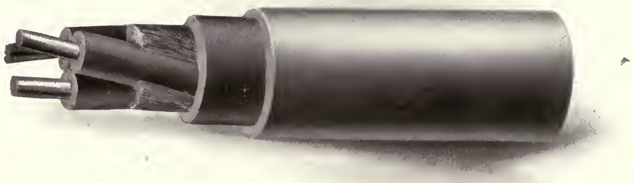
Area Circular Mils	Number and Diameter of Wires in Strand	Approximate Outside Diameter Inches	List Number	Approximate Weight per 1000 Feet Pounds	Approximate Length on a Reel Feet
2,000,000	127 x .1255	2.257	33800	10.945	500
1,900,000	127 x .1223	2.215	33802	10,545	500
1,800,000	127 x .1190	2.172	33804	10,137	500
1,750,000	127 x .1174	2.151	33805	9,934	500
1,700,000	127 x .1157	2.129	33806	9,724	500
1,600,000	127 x .1122	2.084	33808	9,301	500
1,500,000	91 x .1284	2.038	33810	8,899	750
1,400,000	91 x .1240	1.989	33812	8,478	750
1,300,000	91 x .1195	1.940	33814	8,056	750
1,250,000	91 x .1172	1.914	33815	7,843	750
1,200,000	91 x .1148	1.888	33816	7,623	750
1,100,000	91 x .1099	1.834	33818	7,192	750
1,000,000	61 x .1290	1.777	33820	6,753	750
900,000	61 x .1215	1.718	33822	6,310	750
800,000	61 x .1145	1.656	33824	5,856	750
750,000	61 x .1109	1.623	33825	5,629	1000
700,000	61 x .1071	1.589	33826	5,395	1000
600,000	61 x .0992	1.518	33828	4,923	1000
500,000	61 x .0905	1.440	33830	4,432	1000
450,000	37 x .1103	1.397	33831	4,182	1000
400,000	37 x .1040	1.353	33832	4,927	1000
350,000	37 x .0973	1.306	33833	3,685	1000
300,000	37 x .0901	1.257	33834	3,396	1000
250,000	37 x .0822	1.200	33835	3,114	1000

Paper Insulated and Lead Encased Cables

Stranded Annealed Copper Conductor. Thickness of Insulation, 7-32 Inch; Lead, 1-8 Inch

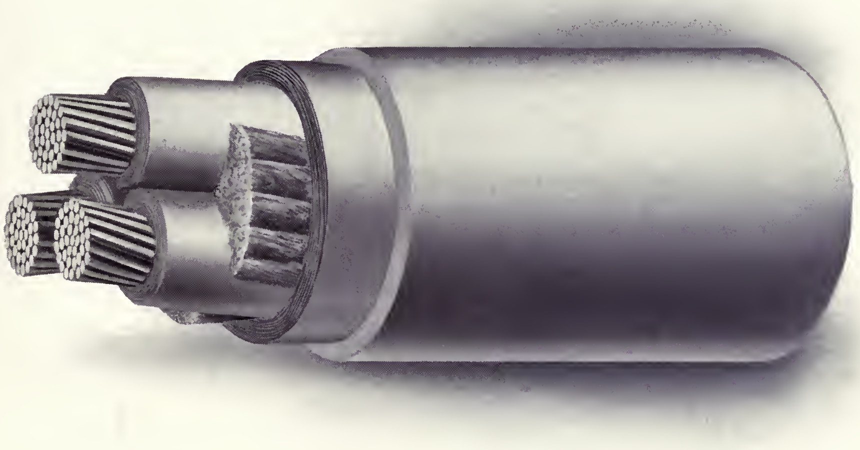
Area Circular Mils	Number and Diameter of Wires in Strand	Approximate Outside Diameter Inches	List Number	Approximate Weight per 1000 Feet Pounds	Approximate Length on a Reel Feet
2,000,000	127 x .1255	2.320	34800	11,184	500
1,900,000	127 x .1223	2.277	34802	10,779	500
1,800,000	127 x .1190	2.236	34804	10,368	500
1,750,000	127 x .1174	2.214	34805	10,124	500
1,700,000	127 x .1157	2.192	34806	9,953	500
1,600,000	127 x .1122	2.146	34808	9,526	500
1,500,000	91 x .1284	2.100	34810	9,122	750
1,400,000	91 x .1240	2.052	34812	8,699	750
1,300,000	91 x .1195	2.002	34814	8,274	750
1,250,000	91 x .1172	1.977	34815	8,059	750
1,200,000	91 x .1148	1.950	34816	7,838	750
1,100,000	91 x .1099	1.896	34818	7,404	750
1,000,000	61 x .1280	1.840	34820	6,962	750
900,000	61 x .1215	1.781	34822	6.515	750
800.000	61 x .1145	1.719	34824	6,059	750
750,000	61 x .1109	1.685	34825	5,828	1000
700,000	61 x .1071	1.652	34826	5,593	1000
600,000	61 x .0992	1.580	34828	5,117	1000
500,000	61 x .0905	1.502	34830	4,622	1000
450,000	37 x .1103	1.460	34831	4,369	1000
400,000	37 x .1040	1.415	34832	4,112	1000
350,000	37 x .0973	1.368	34833	3,847	1000
300,000	37 x .0901	1.319	34834	3,575	1000
250,000	37 x .0822	1.263	34835	3,291	1000


No. 6 B. & S., Solid, Paper Covered, Lead Sheathed


No. 6 B. & S., Solid, Three-conductor, Paper Insulated, Lead Encased Cable

Varnished Cambric Cables

Lead Encased Wires and Cables



A single-conductor varnished cambric cable is made by winding tapes of thin varnished cotton or muslin cloth spirally about the conductor in a sufficient number of smooth, tightly drawn layers to make the required thickness of dielectric. The cotton fabric is saturated with several applications of special non-hardening insulating varnish. The dielectric strength of this material is very high, as a single thickness of cotton well treated with our special varnish will withstand a stress of from eight to twelve thousand volts for five seconds, depending upon the number of coats of varnish with which the cloth has been treated. The varnish prevents the tape from unwrapping when the cable is cut, and permits the adjoining layers of varnished cambric to slide upon each other, thus insuring a concentric condition when the cable is bent. This compound of varnish prevents capillary absorption of moisture between the layers of tape, seals any possible skips in films and precludes air spaces.

In multiple-conductor cables, it is usual to place a portion of the required thickness of insulation in the form of a belt about the core of conductors, as in the case with paper cables. (See page 155.)

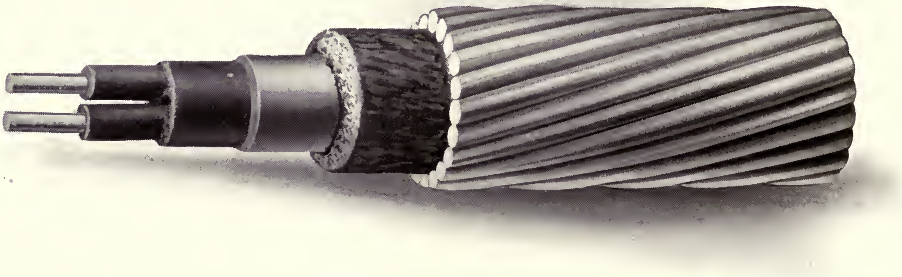
This class of cables is in general more flexible than paper cables, more impervious to moisture, reasonable in cost, and can be used in dry places such as for station wiring without lead sheathing. When no sheathing is required the cable is protected by a cotton braid, or with an asbestos braid for fire protection. These braids are saturated in weatherproof compounds or in slow-burning compounds, as may be required.

We make these cables in any quantity, of any size or type and for any voltage or service condition, to the most rigid specifications.

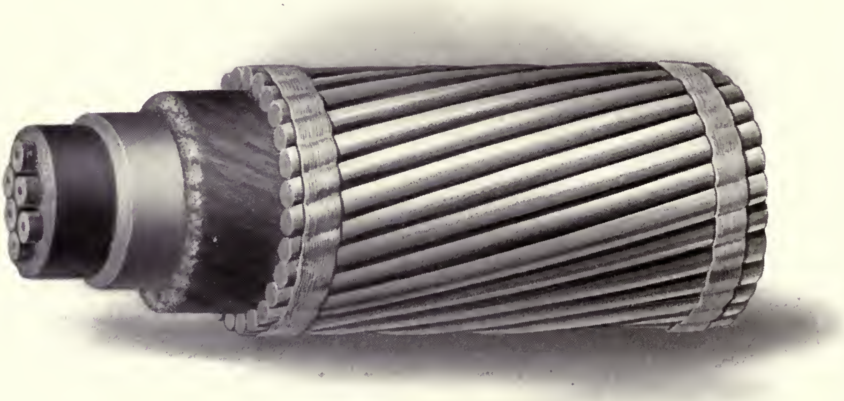
Inquiries containing full information as to working conditions are solicited and prices will be quoted on application.

Lead Encased Wires and Cables

Submarine Cables



Two-conductor Submarine Cable, Lead Encased, Jute Sewed and Armored

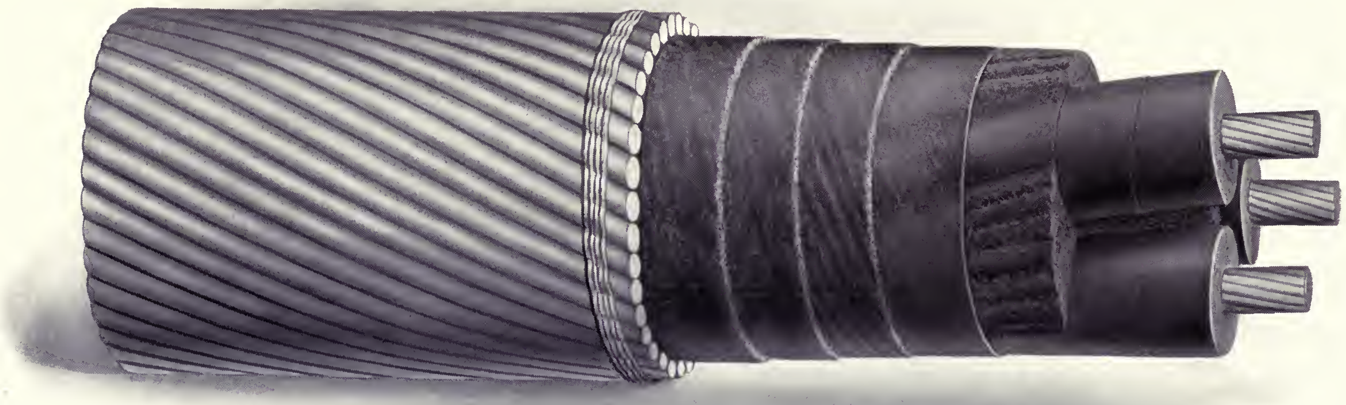


Multiple Conductor Rubber Insulated Signal Cable

We manufacture and install large quantities of submarine cables of every class, for street railways, telegraph and telephone companies and electric light and power plants. These are used for crossing rivers, bays, ponds or lakes. We are well prepared for furnishing this class of material to the most exacting specifications.

Full information as to the purpose for which the cable is to be used, location, depth of water and working conditions should accompany requests for prices. Inquiries solicited.

Lead Encased Wires and Cables

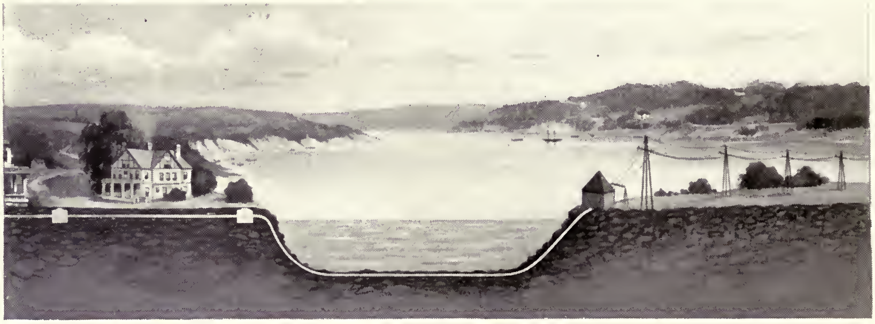


Submarine Cable for Transmitting Power at 25,000 Volts

Three-conductor, 2/0 cable, 19 wires in each strand; rubber insulation $\frac{12}{32}$-inch thick and taped. Three conductors laid up with jute fillers and taped all over. Covered with three jute servings in reverse layers. Thirty-five galvanized iron armor wires, each .25-inch in diameter. Outside diameter of cable, 3.41 inches. This particular cable, which is 7,000 feet long, has been in service under the St. Lawrence River for one year. A similar cable has been in service three years. Both are giving entire satisfaction.

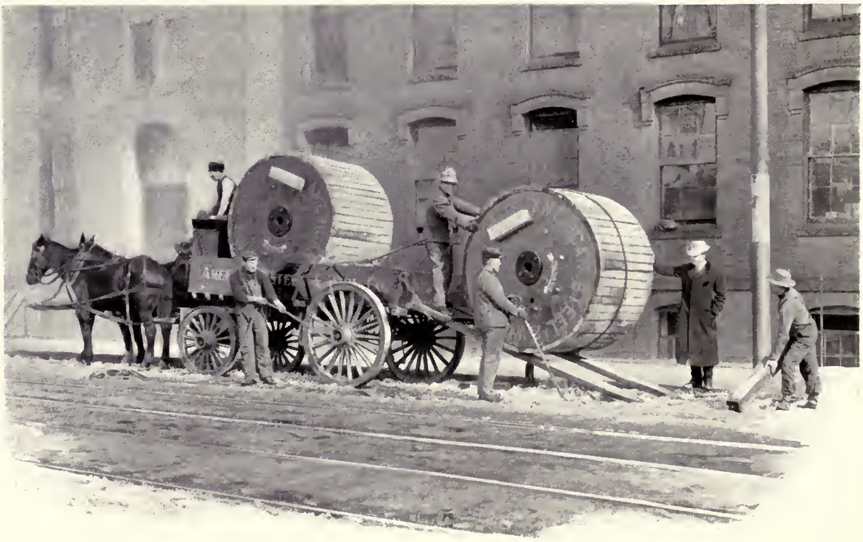
Installation of Underground Cables

Installation of Underground Cables



In this article no attempt will be made to indicate all the details of cable laying, but rather to outline very briefly the general method of installing underground cables and to emphasize the importance of some parts of the work in connection therewith. As stated elsewhere, this company will furnish, install and guarantee its underground cables for almost any class of service. Rubber covered telephone or telegraph cables, electric light and power cables, single or multiple conductors insulated with rubber, paper or varnished cambric, made to carry current for any service at any pressure within practical working limits.

We maintain a fully equipped cable department, supervised by experienced and able engineers and manned by competent cable workmen, which has for many years and with marked success attended to all matters pertaining to underground and submarine cable installations. Through this department, we are at all times prepared to install cables, to make estimates or to advise customers regarding specifications, costs of installations and so on, or to furnish competent supervisors for installations made by the customer himself.



Unloading Reels

Installation of Underground Cables

Handling Lead Cables

Cables are shipped from the factory on well constructed wooden reels of suitable size to accommodate one or more lengths of cable. As explained on page 50, credit will be allowed for empty reels when they are returned to our factory in good condition.

When coiling a cable on a reel, the first end, usually termed the test end, is put through a slanting smooth hole in the side of the reel, so as to have both ends of the cable accessible for testing before shipment. After testing, both ends are capped or sealed, thus protecting the cable insulation from moisture. Each reel is given the most rigid inspection before leaving the factory, and the test end protruding through the side of the reel from 12 to 18 inches is boxed over. The reel itself is lagged from flange to flange with heavy wooden slats nailed to the flanges and finally secured with heavy wires encircling the slats so as to thoroughly protect the cable from injury in transit or while standing on the street.

Transporting such reels of cable from the railroad to the manhole is intrusted only to experienced truckmen, and if a low wagon is not available and a high wagon must be used, the reels of cable are carefully lowered from the wagon by means of a windlass and skids and are not allowed to drop to the ground. To avoid the loosening of the cable, the reels are rolled in the direction pointed by the arrow painted on the side of the reel.

The reel of cable is then placed at the manhole over the duct into which the cable is to be drawn, in such a way that the cable will unwind from the top of the reel. It is next mounted on screw jacks and not until then are the slats removed, care being taken that no nails come into contact with the cable or are left in the flanges to do damage.

The utmost care is always taken not to bend the cable sharply, not to break through, cut, abrade, kink or dent the lead sheath, and above all not to allow the slightest trace of moisture to enter the ends of the cable after the seals have been broken. A failure to observe these points may lead to the ruination of the cable. The useful life of an underground cable is determined by that of the insulation, which in turn usually depends upon the integrity of the lead sheath.

The Conduit System

When cables were first put under ground a trench was dug to a safe distance below the street surface, into which the cable was laid. It was then covered with sand and the trench filled in. Later, this method was improved by first placing in these trenches long rectangular boxes or troughs made of yellow pine thoroughly creosoted with dead oil or tar. The cable was laid into this box and was entirely surrounded with hot pitch or other bituminous compound. A wood cover was then placed on the trough, after which the trench would be filled in. Such solid systems are still extensively used in foreign countries and to some extent here in private rights of way, and are considered quite safe under certain conditions. However, in this case, when a cable becomes defective, the whole trench has to be dug up in order to replace or repair such defects.

This led to the adoption of what is known as the *flexible duct* or *drawing-in* system, which is built under the pavement of streets in thickly settled portions of a city, in a manner that will permit of drawing in the wires and cables at any time after the completion of the subway. This system also allows extensions or rearrangements of cables as may be deemed advisable from time to time. At the

Installation of Underground Cables

present time there is a large number of different kinds of conduits. They are made of Bituminized Fibre, Iron and Cement, Terra-Cotta, and so on, each type of which has some redeeming quality of its own.

Any type of conduit for lead encased cables should possess the following qualities. It should afford a thorough mechanical protection to the enclosed cable, securing it from accident during street excavations. It should be absolutely proof against fire, acid, gas, water and electrolysis, thus protecting the cable, and maintaining it for a long period of time. The conduit should also have sufficient mechanical strength to resist the ordinary destructive influences to which street structures are exposed. The bore of the ducts should be smooth, straight, and in perfect alignment. The latter, however, does not always receive sufficient attention by contractors.

A few years ago a three-inch diameter duct was considered sufficiently large, but for feeder cables called for to-day, which are often over three inches in diameter, nothing less than a three and one-half-inch bore should be used, and if very long sections of cables are to be installed, the bore should be even larger.

After a conduit contractor has finished building the underground duct system, and before he leaves it, the system should not be accepted until after it has been tested by drawing through each duct a test mandrel about twenty-four inches in length and one-quarter of an inch less in diameter than the bore of the duct.

Manholes

Manholes are usually built at street intersections or turns in the conduit line to afford a place for jointing the cables. The distance between these manholes depends upon local conditions. It is safe to say that this limiting distance where large cables are to be installed should be 500 feet, for in pulling larger lengths the cable sheath is subjected to a severe strain, and this should be avoided. Manholes, especially for high tension cables, should, whenever possible, be built spacious, be well drained, well ventilated, and they should be kept clean and dry. Their design should be such as to afford the best opportunity for bending the cable ends projecting from the ducts to a position on the wall where they are to be racked and jointed. On the following two pages are shown in outline a typical two-way and a four-way manhole as recommended by the Committee on Power Distribution of the Railway Engineering Association. This construction should be followed whenever possible.

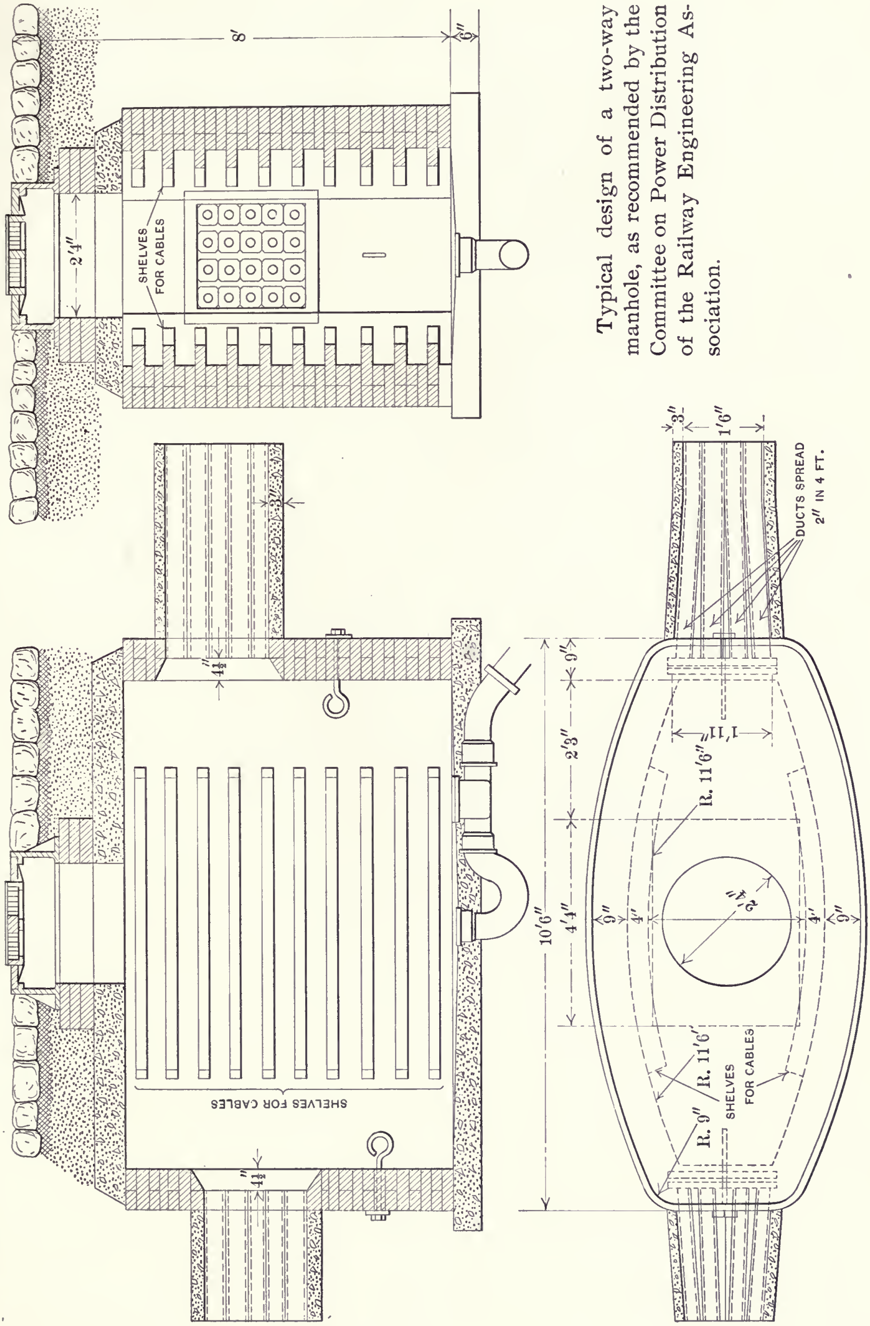
Ample facilities should be provided in each manhole, either by shelves or adjustable racks for supporting the cables in place. Many cables are ruined on account of insufficient and inadequate fittings. Some attention should also be given to locating the lower and the top ducts in a manhole, so as to enable the cables to be drawn in without damaging them. The manhole cover should be over the center of the manhole, making it easy to set a rigging when installing cables, and making it more difficult for careless workmen to use the cables as steps in entering or leaving the manhole, which practice will soon ruin any cable.

When possible, a good ground should be provided in each manhole for the purpose of bonding cables, when it becomes necessary to do this in order to protect the cables against stray currents which might destroy the lead sheath and finally the insulation by electrolysis.

Choice of Ducts

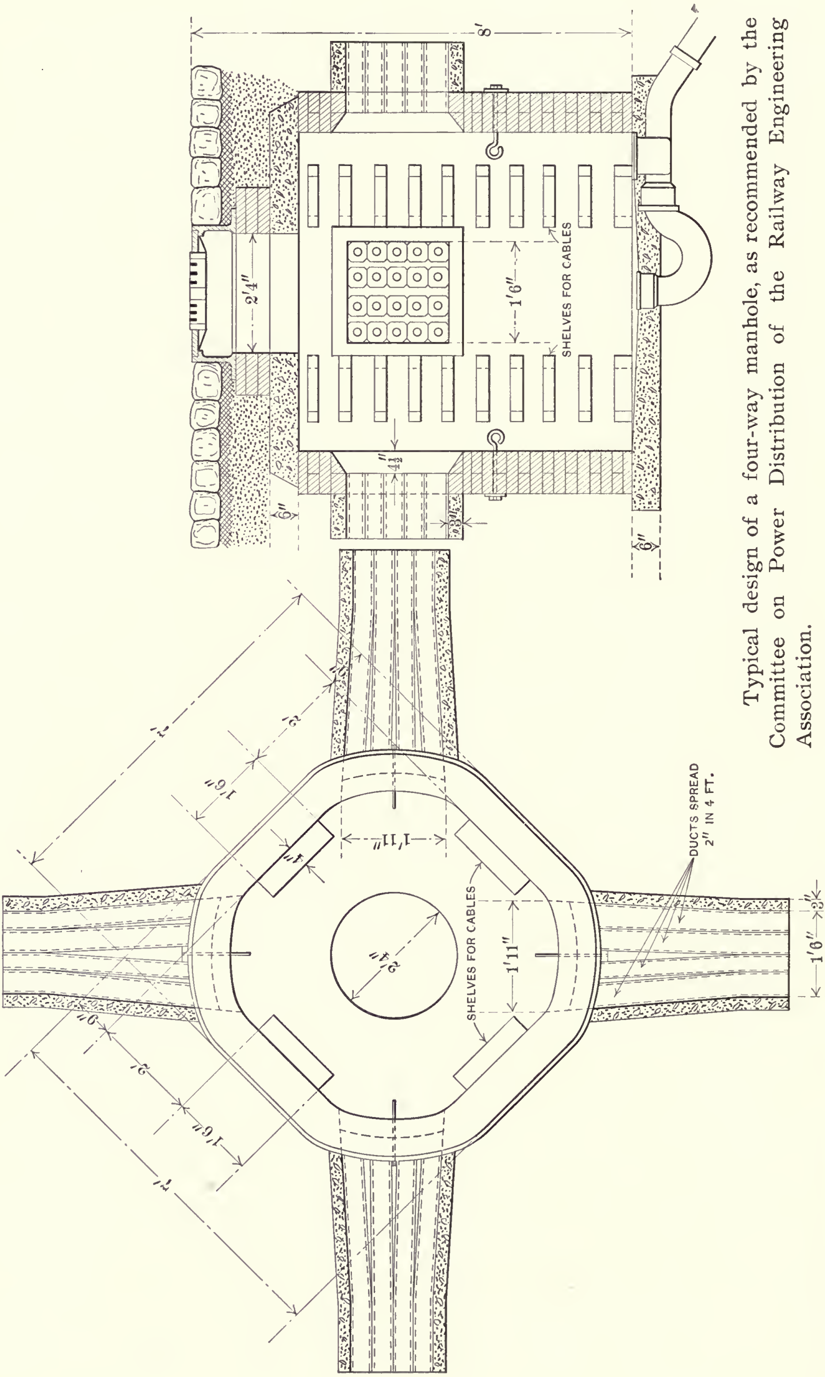
Before drawing any cables into a new conduit system, it is often a question to decide which of the ducts shall first be used. Workmen when about to install

Installation of Underground Cables


8'
6"
2'4"
SHELVES FOR CABLES
3"
4½"
4½"
SHELVES FOR CABLES
10'6"
9"
2'3"
4'4"
1'11
R. 11'6"
2'4"
4"
4"
9"
9"
R. 11'6"
R. 9"
SHELVES FOR CABLES
3"
1'6"
DUCTS SPREAD 2" IN 4 FT.

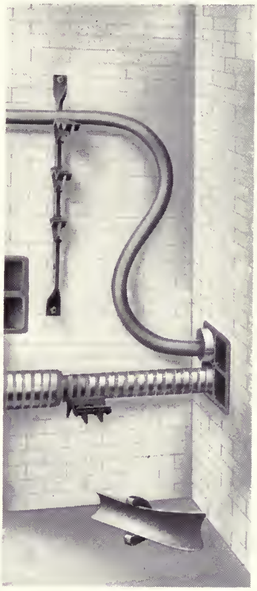
Typical design of a two-way manhole, as recommended by the Committee on Power Distribution of the Railway Engineering Association.

Installation of Underground Cables

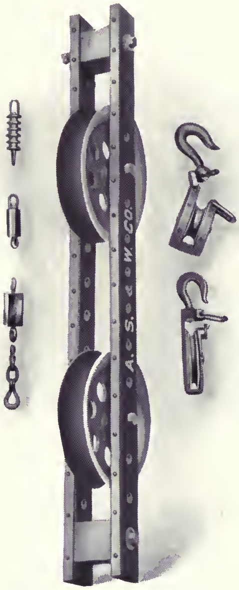

8'
2'4"
1'6"
SHELVES FOR CABLES
4½"
6"
3½"
6"
1'11"
2'4"
1'11"
SHELVES FOR CABLES
DUCTS SPREAD 2" IN 4 FT.
1'6"
3"
9"
2'
1'6"
7'

Typical design of a four-way manhole, as recommended by the Committee on Power Distribution of the Railway Engineering Association.

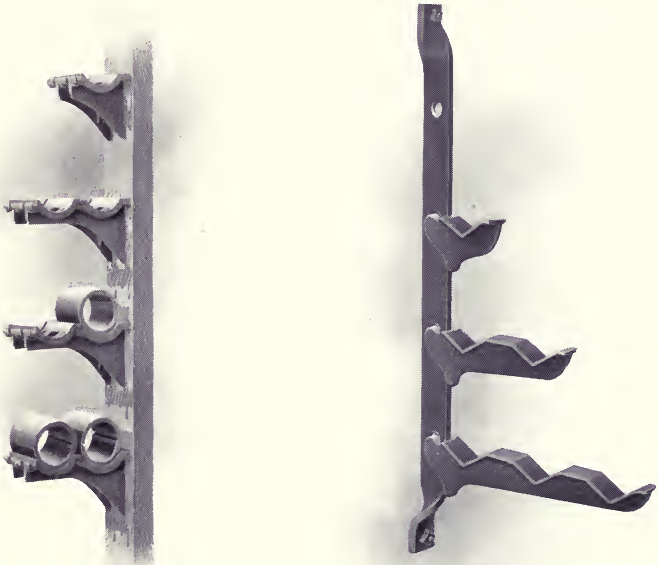
Installation of Underground Cables



Arrangement of Cables in Manhole



Appliances Used in Connection with Installation of Cables



Typical Manhole Racks for Cables

Installation of Underground Cables

cables may have been told to use any one of the ducts, and naturally they draw into those which are most convenient, without any consideration for other cables that may be installed later. There are cases where the manhole is completely blocked by the first few cables installed. But there is another important reason why the ducts to be used for power cables should be very carefully selected, as will be seen from the following.

We are often requested by customers to stipulate the amperage and to guarantee a cable for such current carrying capacity. It is not possible to foretell the exact current carrying capacity of a cable without previously knowing all the controlling factors which would influence the temperature rises in such a cable. Some of the most important factors are the natural temperature of ducts and manholes, amount of moisture present, condition and kind of soil surrounding the conduit, and exact location of the cable in the duct with respect to other cables which have previously been installed. All of these greatly influence both the radiation or dissipation of heat generated in each conductor or cable, and the current carrying capacity of the conductor.

Usually, the coolest and best heat radiating ducts are those located at the lower corners of the system, next are those nearest to the outside of the system, and lastly the middle and top ducts which not only take up heat from the lower cables, but must dissipate heat through adjoining ducts. Attention to these points when planning a new system may prove very profitable in the end.

Regarding the selection of cables, it should be borne in mind that those insulated with rubber compound dissipate heat more readily than those insulated with paper or other fibrous material, other conditions being equal. On the other hand it has been found that a cable insulated with an oil saturated paper will stand its load for a longer period of time at a high temperature than one insulated with rubber compound, without showing signs of deterioration, that is, if not too much resinous material has been used in making up the paper insulation. High tension cables insulated with varnished cambric should not be operated continuously at higher temperatures than rubber insulated cables, preferably not above 145 degrees Fahrenheit, whereas paper cables may be operated for short periods at about 160 degrees Fahrenheit. It should also be borne in mind that under similar conditions a single conductor cable dissipates the heat faster than two or more conductors enclosed in a single sheath.

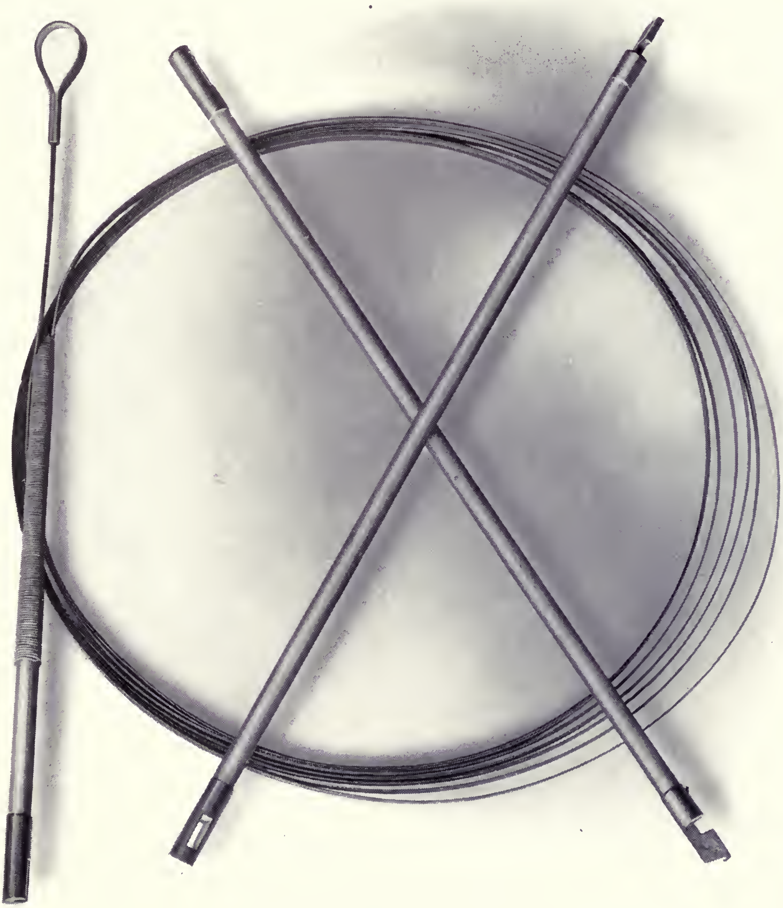
To economize in space, as many as six cables are at times drawn into one duct. This may be an advantage, but it also has its disadvantages, for the reason that if one cable should burn out there is every possibility of burning up the remaining cables, and all six would be out of commission and would have to be replaced. But, nevertheless, the two wires of the same circuit should always be brought as near together as possible, so as to reduce the passage of magnetic flux between them, whether this flux proceed from themselves or from other wires.

It has been recommended by the committee of railway engineers on power distribution that all cables passing through iron pipes be covered with a weatherproof braid. As explained on page 20, no single conductor carrying an alternating current should be placed in an iron duct. To minimize the loss due to self-induction, the two, three or four legs of a single-phase, three-phase or quarter-phase alternating circuit should, whenever possible, be made up into one multiple-conductor cable having a common lead sheath. Pressure wires may be included whenever required.

Drawing Cables into Ducts

Installation of Underground Cables

After having decided upon the duct into which the cable is to be drawn, preparations are made to wire the duct and to thoroughly clean and free it from any obstructions which might injure the cable when being drawn in. To accomplish this, a snake wire or a rodding stick, of which there are several types, one of which is shown below, is worked through the duct. These rodding sticks are one inch in diameter and from three to five feet in length and have on each end a coupling for jointing the rods into one continuous length as they are pushed into the duct.



Rodding Sticks and Snake Wire

A workman pushes one of these rods into the duct, couples a second onto the first rod and again pushes it ahead and so continues the operation until the first rod put into the duct extends through to the next manhole. Then to the end of the last

Installation of Underground Cables

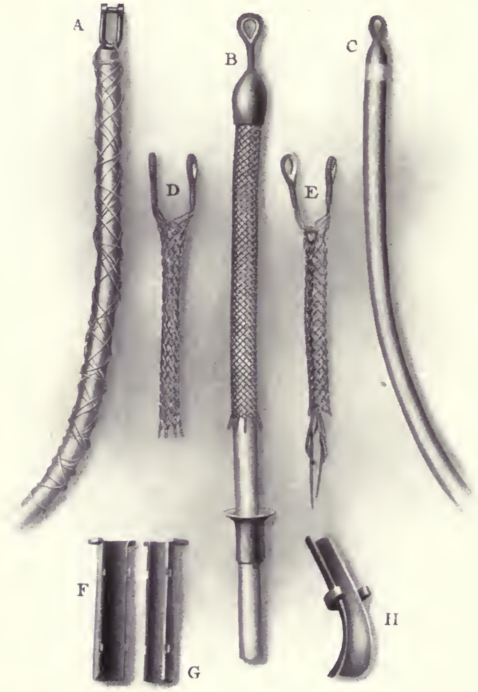
rod a No. 10 or No. 12 B. W. gauge galvanized wire of sufficient length is attached and this is drawn through the duct with the rods. This operation is continued from manhole to manhole until all the ducts have been wired.

If the sections of ducts are of short lengths, rods may not be necessary, and a snake wire alone may be used. This latter is also better adapted to wiring ducts with curves, but it cannot be used in very long lengths, owing to the friction encountered.

By means of the galvanized wire, a suitable rope to which is attached scrapers, gauges and brushes or swabs, is next drawn through the duct, so as to make sure that all is clear for the cable. These gauges should be about three-eighths of an inch larger than the cables to be installed.

The sealed ends of the cable are examined to see that they are perfect, and then a wire pulling grip of some form (see below) is drawn over the cable end.

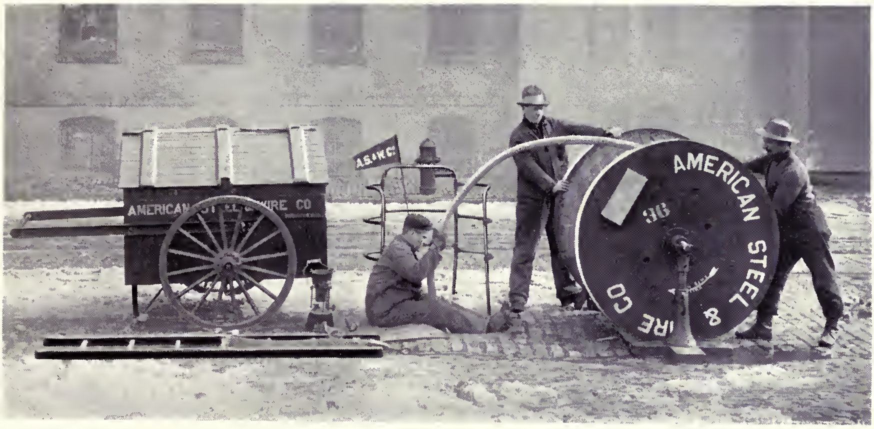
To the end of this grip is next fastened the end of a steel or manila pulling rope, which in the meantime has been drawn through the duct ready for pulling. Proper cable protectors are placed in the mouth of the duct. These protectors are usually made of leather and are so placed in the end of the duct that the cable will not be damaged. The cable should now reach from the top of the reel to the mouth of the duct by a graceful curve, without touching at any intermediate point, as shown on next page. The pulling can be done by capstan, winch, motor truck, horses or, if it is a small cable, by hand. When guiding the cable into the duct, a small amount of common grease should be spread on to the cable so as to allow it to slide more easily and lessen the strain on the cable. Enough extra cable should be drawn into the manhole to provide for racking around the manhole and making the joints. At times a long length of cable has to be drawn, and for this reason a rigging as illustrated is used. This has large sheaves that will not damage the cable. Many times cables are injured by pulling them over sheaves which are too small for the cable. During the installation no cable should be bent sharper than a radius equal to ten diameters of the cable.



Appliances Used During Installation of Underground Cables

If it is not intended to join the cables as soon as they are drawn in, the caps or seals should be examined to see that they are safe before leaving the work. The cable should be protected at the edge of the duct and it should not be left hanging loosely or lying on the bottom of the manhole, but should be placed on the racks provided for it.

Installation of Underground Cables


AMERICAN STEEL & WIRE CO
A.S.&W.C.
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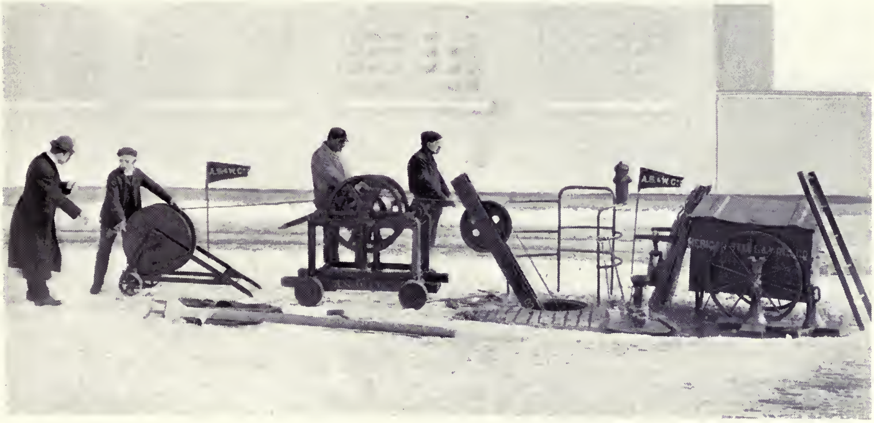
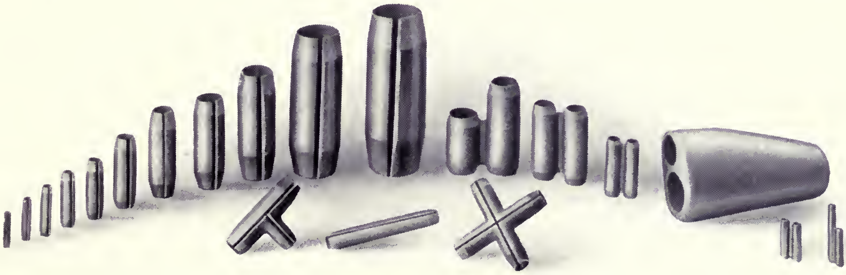
AMERICAN STEEL & WIRE CO

Unreeling Cable into Duct



Pulling in Cable with Capstan



Copper Couplings

Installation of Underground Cables

If the cables have paper insulation, they should never be installed at a temperature below 40 degrees Fahrenheit without first warming them up by charcoal fires or other means, so as to make them more flexible and avoid any possibility of cracking the insulation. Also when cables are being racked around the manhole they should be thoroughly warmed if the temperature is low.

Before jointing, cut the ends back far enough to be positive that there is no moisture present. A test for moisture should be made if there is any reason to suspect its presence.

The Jointing of Cables

It is generally admitted that the greater part of trouble which occurs on high tension cables is due to poorly made joints, or to the presence of moisture or cracks in the insulation near the joints. With good material and careful and competent workmen, the insulation of the joint can be made as reliable and as durable as that on any other part of the cable. The construction of a joint is therefore of prime consideration, and unless the purchaser has at his command experienced and thoroughly reliable cable workmen, he would do well to contract with the manufacturer, who has every facility for doing this class of work, for the complete installation of the cable.

In the making of a perfect joint,

(*a*) High grade insulating materials are carefully chosen to suit the special conditions.

(*b*) The work is done by reliable and experienced cable men under the supervision of an expert who critically inspects all work.

(*c*) Every trace of moisture is excluded from the joint and adjacent parts of the cable.

(*d*) The cable should never be bent to a radius of less than eight times its diameter for rubber or cambric insulation, or ten diameters for paper insulation. The latter as already explained should in extreme cold weather be warm before being bent at all.

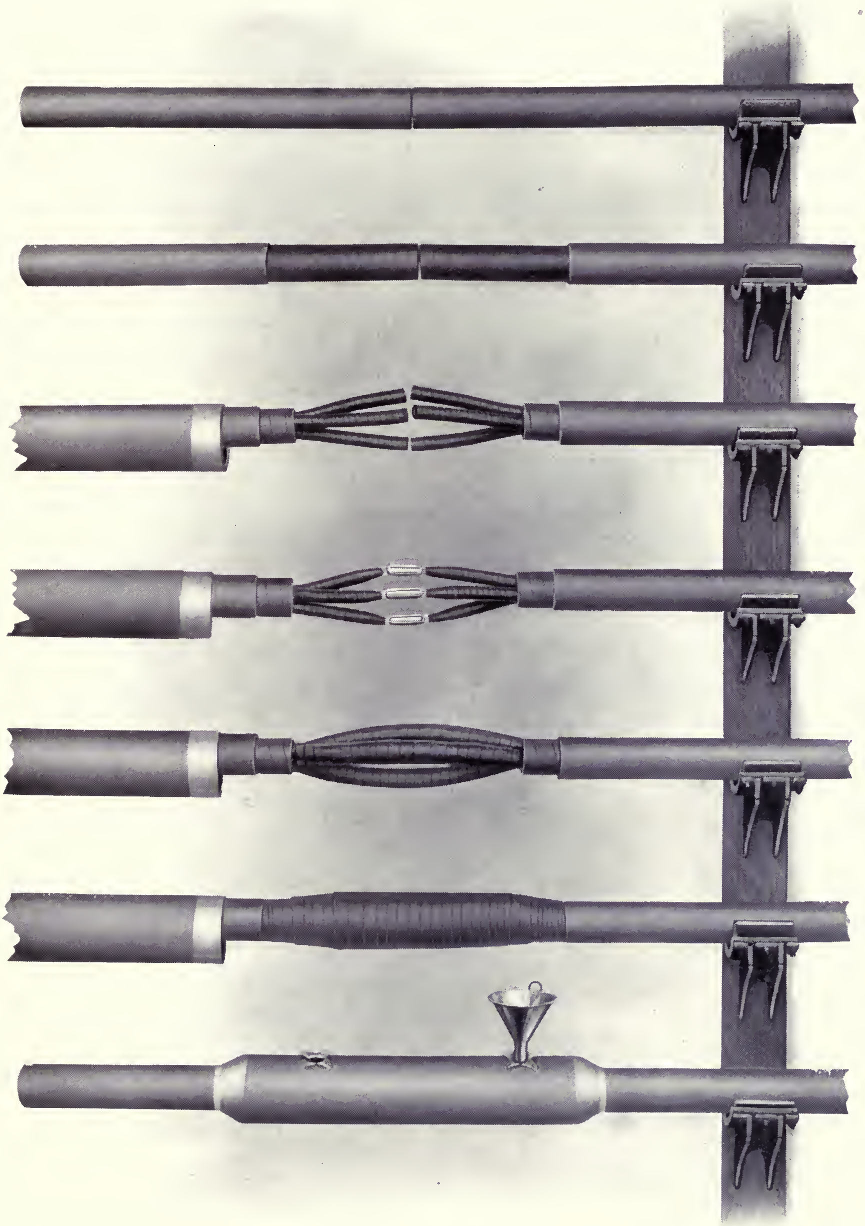
(*e*) The layers of insulating tape are drawn tight to exclude air and are made to overlap each other.

(*f*) The lead sleeve is properly proportioned, well wiped on and entirely filled with compound previously heated to the correct temperature. Two holes are made in the top of the finished lead sleeve, one near each end as shown on next page, to permit of filling with the compound. As the compound settles, the sleeves have to be refilled from time to time until they are entirely full, then the holes through the sleeve are sealed.

The length of a joint should be in proportion to the size of the conductor, avoiding short joints where it is possible and the insulation on a joint should be at least 20 per cent. thicker than that on the cable itself. Before drawing the lead sleeve over the newly made joint, the new insulation should be well dried out to remove all trace of moisture taken up from the hands of the workmen or elsewhere.

The various steps in the making of a 3-conductor high tension cable joint are fully illustrated on the next page. Sections of a straight-way joint, also of three and four-way branch joints of suitable design, are shown on pages 177 and 178. The Y-shape or parallel branch joint are more easily made, take up less space and are stronger than the right angle joint.

Installation of Underground Cables



Showing the Various Steps in the Making of a Three-conductor, Paper Insulated Lead-covered Cable Joint

Installation of Underground Cables

Jointing Materials

One of the most important features to be considered in making a joint as already mentioned, is in the choice of correct jointing materials. These should in all cases be of the very best quality.

We keep on hand at all times a large supply of all high grade insulating materials used in jointing the various styles of cables listed in this catalogue. Rubber tapes of various kinds and sizes, pure rubber and rubber compounds. All sizes of treated paper and varnished cambric tapes, high grade compounds which we have developed during the past few years and which are giving perfect results. We can furnish on short notice, lead sleeves of any style or dimensions, and all special tools and appliances ordinarily used in cable installations, many of which are illustrated herein.

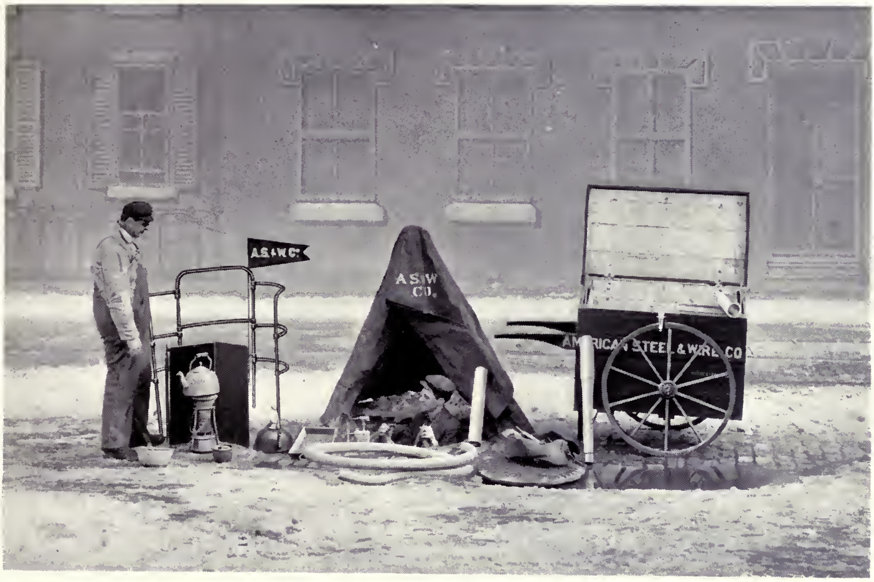
Our copper jointing sleeves are made from pure copper. They are made in the most suitable lengths for regular underground joints, tinned and well finished. Each is provided with an opening along its entire length so as to permit of the solder flowing freely throughout the joint when made, thus insuring a good soldered union. Both ends of the sleeve are beveled off, and sharp edges which would have a tendency to cause a puncture through the insulation after the joint has been finished are removed.

Specials, such as Y or T sleeves, are made up on short notice when customers' requirements are known.

Standard Dimensions of Copper Sleeves for Jointing Cables

List Number	Size of Conductor	Outside Diameter of Conductor Inches	Outside Diameter of Sleeve Inches	Thickness of Copper Inches	Length of Sleeve Inches	Weight per 100 Sleeves Pounds
2000 S	2,000,000	1.6302	2.168	.268	6.00	280
1750 S	1,750,000	1.5246	2.027	.251	5.65	242
1500 S	1,500.000	1.4124	1.879	.233	5.30	200
1250 S	1,250,000	1.2892	1.715	.212	4.90	150
1000 S	1,000,000	1.1520	1.532	.190	4.45	110
900 S	900,000	1.0935	1.454	.180	4.25	88
800 S	800,000	1.0305	1.360	.170	4.05	76
750 S	750,000	.9981	1.327	.162	3.95	67
700 S	700,000	.9639	1.282	.159	3.80	62
600 S	600,000	.8928	1.187	.147	3.60	52
500 S	500.000	.8134	1.082	.134	3.35	45
400 S	400,000	.7280	.968	.120	2.10	36
300 S	300,000	.6321	.841	.104	2.75	23
250 S	250,000	.5754	.766	.095	2.60	16
254 S	0000	.5275	.702	.087	2.45	14
253 S	000	.4700	.625	.078	2.25	10
251 S	00	.4180	.556	.068	2.10	7
250 S	0	.3730	.496	.062	1.95	4
255 S	1	.3315	.441	.055	1.80	. .
256 S	2	.2919	.388	.048	1.70	. .
257 S	3	.2601	.347	.043	1.60	. .
258 S	4	.2316	.308	.038	1.50	. .
259 S	5	.2061	.275	.034	1.40	. .
260 S	6	.1836	.244	.030	1.25	
261 S	7	.1635	.218	.027	1.25	. .
262 S	8	.1455	.194	.024	1.25	. .
263 S	9	.1305	.172	.022	1.25	. .
264 S	10	.1155	.154	.020	1.25	. .

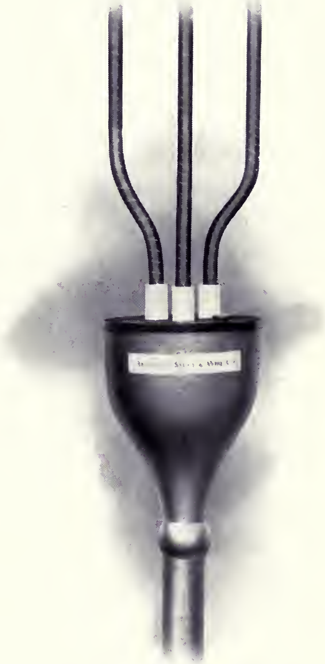
Installation of Underground Cables


A.S.&W.Co
A.S.W.
CO.
AMERICAN STEEL & WIRE CO

Making Underground Cable Joints in Stormy Weather

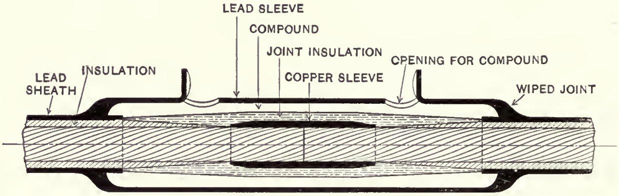
LEEDS & NORTHRUP CO
PHILADELPHIA U.S.A.

Testing Instrument

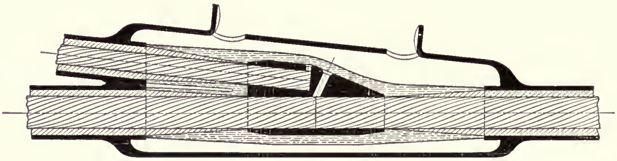


End Bell for Three-conductor Cable

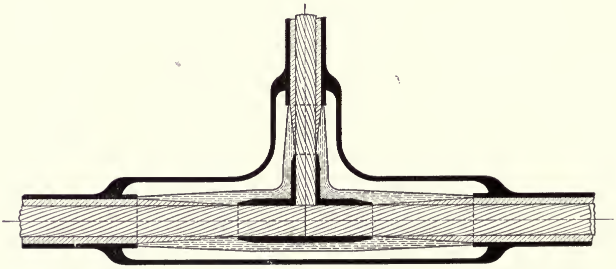
Installation of Underground Cables


LEAD SLEEVE
COMPOUND
JOINT INSULATION
COPPER SLEEVE
OPENING FOR COMPOUND
WIPED JOINT
LEAD SHEATH
INSULATION

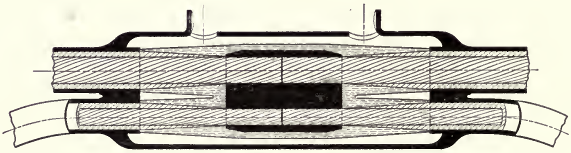
Straight-way Single Conductor Cable Joint



Single Conductor Y-shape Branch Joint

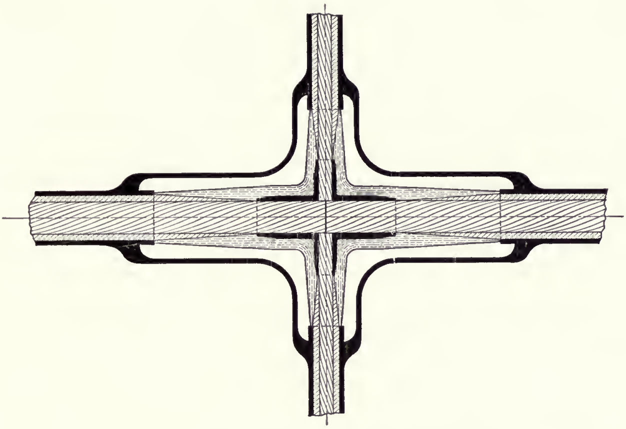


Single Conductor Right Angle Branch Joint

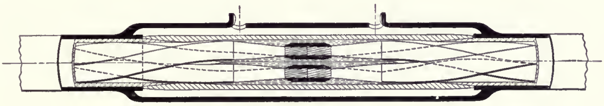


Two Parallel Conductor Branch Joint

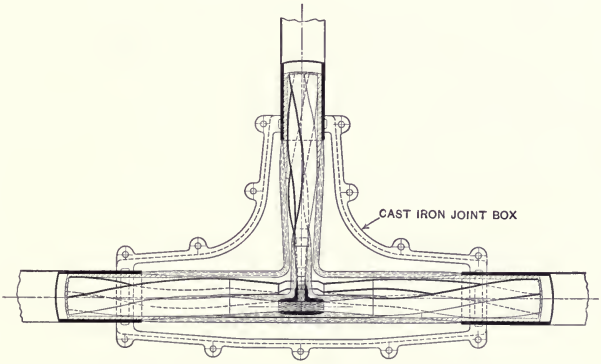
Installation of Underground Cables



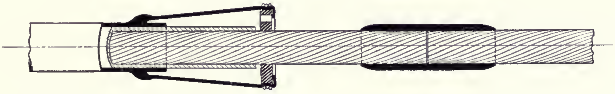
Two Right Angle Conductor Branch Joint



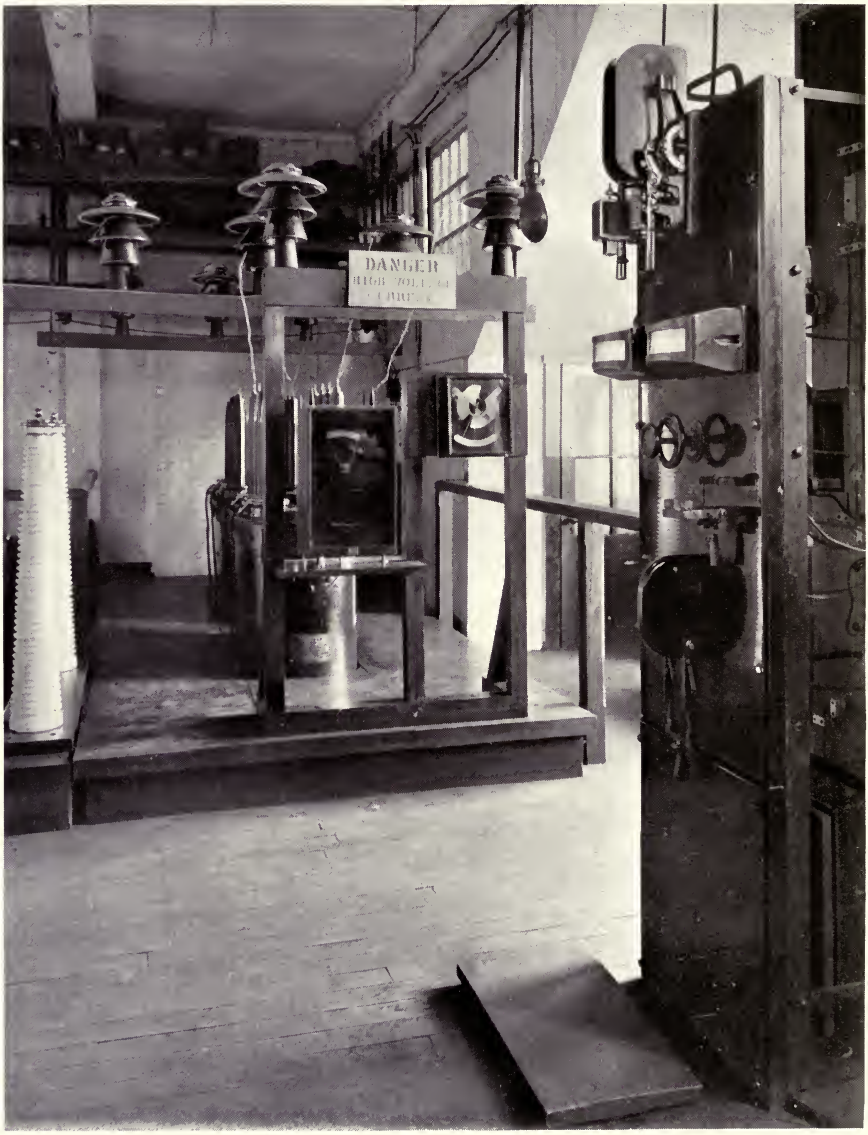
Straight-way Three-conductor Cable Joint



Three-conductor Right Angle Branch Joint



Insulated Single Conductor Cable Connection to a Bare Cable


DANGER
HIGH VOLTAGE

Apparatus for Making High Potential Tests

An Abridged Dictionary
of
Electrical Words, Terms and Phrases

In compiling this Dictionary we have quoted chiefly from Houston's "Dictionary of Electrical Terms, Words and Phrases," by courtesy of *The McGraw-Hill Book Company, of New York.*

Electrical Dictionary

a. A symbol for acceleration.

A.C. A contraction for alternating-current.

Absolute Temperature. That temperature which is reckoned from the absolute zero, −273° C, or −459° F.

Acceleration. A change of motion. The time-rate of change of velocity.

Accumulator. A word sometimes applied to a current accumulator. A Leyden jar or condenser. A secondary or storage battery.

Acheson Effect. The change in the electromotive force of the secondary of a transformer due to changes of temperature in its core.

Aclinic Line. A line connecting places on the earth's surface which have no magnetic inclination. The magnetic equator of the earth.

Acoutemeter, Electric. An apparatus for electrically testing the delicacy of hearing.

Actino-electricity. Electricity produced in crystalline substances by the action of radiant energy.

Active Component of Exciting Current. The active current in an alternating current circuit as distinguished from the wattless current. In an alternating-current circuit the component of current which is in phase with the E.M.F. and the effective and apparent conductance.

Active Current. A working component of a current in an alternating-current circuit as distinguished from a wattless component of current. The component of an alternating-current that is in phase with the impressed electromotive force.

Active Loop. A single loop in a circuit that is traversed by an electric current.

Activity. Power. Rate-of-doing work. The work done per second, in uniform working.

Activity, Unit of. A rate of working that will perform one unit of work per second. In C.G.S. units, the activity of one erg per second. This unit is very small. The *watt* is taken as the practical unit of power and is equal to ten million ergs per second. Seven hundred and forty-six watts equals one horse-power.

Acylic Machine. Sometimes called unipolar. A continuous current generator in which the voltage generated in the active conductors maintains the same direction with respect to those conductors.

Adapter. A screw-nozzle fitted to an incandescent electric lamp and provided with a screw-thread to enable it to be readily placed on a gas bracket, or chandelier, in the place of an ordinary gas burner. A device which permits incandescent electric lamps of one manufacture to be readily placed in the socket of a lamp of another manufacture.

Adhesive Tape. A tape covered with insulating material and possessing adhesive properties, employed for covering bared conductors, at joints, or other similar places.

Adjuster for Lamp Pendant. Any device for adjusting or altering the height or position of a pendant lamp.

Admittance. The reciprocal of the impedance in an alternating-current circuit. The apparent conductance of an alternating-current circuit or conductor.

Advanced Quadrature. In an alternating-current circuit the condition of being 90° in phase ahead of some particular E.M.F., flux, or current.

Aerial Conductor. An overhead conductor.

Aero-ferric-circuit Transformer. An open-circuit transformer.

Ageing of Electric Incandescent Lamp. A gradual decrease in the efficiency of an electric incandescent lamp due either to the age coating of its chamber, or to the deterioration of its filament.

Ageing or Transformer Core. Increase in the hysteretic coefficient in the iron of a transformer core during the first few months of its commercial operation, from its continued magnetic reversals at comparatively high temperature.

Agone. A line connecting places on the earth's surface where the magnetic needle points to the true geographical north. The line of no declination.

Air-condenser. A condenser in which air is the dielectric.

Air-core Transformer. A transformer which is destitute of a core other than that of air.

Air-gap. In a magnetic circuit, any gap or opening containing air only.

Air-path. The path a disruptive discharge takes through the air.

Air-reluctance. The reluctance of that portion of a magnetic circuit which consists of air.

Air-space. The space that exists between the surface of an armature and the polar surface within which it rotates. The space between opposed surfaces of a comb lightning-arrester.

Alarm, Electric. Any automatic electric device by which attention is called to the occurrence of certain events, such as the opening of a window, the stepping of a person on a mat, the rise or fall of temperature beyond a certain predetermined point, etc., by the closing or opening of an electric circuit. A device for calling a person to a telegraphic or telephonic instrument.

Alive. A name sometimes given to a live wire or circuit. An active wire or circuit.

Alternating. Periodically changing in direction.

Alternating Continuous-current Commutating Machine. A secondary generator for transforming from alternating to continuous currents by the aid of a commutator.

Alternating-current Dynamo-electric Machine. A dynamo-electric machine producing alternating currents in its external circuit.

Alternating-current Phase-meter. An instrument used to determine the phase difference between two alternating currents.

Alternating-current Potentiometer. A potentiometer suitable for measuring the difference of pressure in an alternating-current circuit.

Alternating-current Power. The product of the effective alternating-current strength, the effective pressure under which that current is supplied, and the power factor. With sinusoidal electromotive forces and currents, the product of the effective current strength, the effective pressure under which that current is supplied, and the cosine of the phase-difference between the two.

Alternating-current Rotary Transformer. A rotary transformer for transforming alternating into continuous-currents, or vice-versa.

Alternating Currents. Currents which flow alternately in opposite directions. Currents whose directions are periodically reversed and which, when plotted, consist of half-waves of equal area in successively opposite directions from the zero line. An alternating current equals the electromotive force divided by the impedance, or

$$I = \frac{E}{Z} = \frac{E}{\sqrt{R^2 + X^2}}$$

$$= \frac{E}{\sqrt{R^2 + \left(L\omega - \frac{1}{J\omega}\right)^2}}$$

This expression represents Ohm's law for alternating currents. It may be solved by complex quantities or vectorilly.

$Z = \sqrt{R^2 + X^2}$, Impedance of circuit.
R = Ohmic resistance of circuit.
X = Reactance of circuit in ohms.
L = Coefficient of self induction in henrys.

J = Capacity of the circuit in farads.
$\omega = 2\pi f$, angular velocity, where
f = the number of cycles per second or frequency.

For a circuit consisting of two parallel copper wires each of a radius r, and having an interaxial distance d between them, the total length of the entire circuit being l feet, the coefficient of self induction in henrys will be

$$L = \frac{30.5\, l \left(.5 + 4.6 \text{ Log } \frac{d}{r}\right),}{10^9}$$

and for iron wire when the current density is low the self induction in henrys will be

$$L = \frac{30.5\, l \left(75 + 4.6 \text{ Log } \frac{d}{r}\right)}{10^9}$$

The radius r, and the distance d, must be expressed in similar units of length. The drop in voltage for an alternating-current circuit =

$$I \sqrt{R^2 + X^2}$$

(See Current, Electric.)

Alternation. A change in direction. A change or reversal in the direction of an electromotive force or current. A single vibration or oscillation as distinguished from a complete cycle or double vibration.

Alternation, Periodicity of. The number of alternations per second produced by a generator.

When any particular periodicity or frequency is spoken of, as, for example, 250 alternations per second, 125 complete periods or cycles per second are meant.

Commercially the word alternations is used for half-periods or double-frequencies. A dynamo with 250 alternations per second has 125 periods per second.

Alternator, or Alternating-Current Generator. One which produces alternating currents, either single-phase or polyphase.

Alternator, Compensated. An alternating-current dynamo-electric machine for sustaining a uniform voltage at some point of its circuit under varying loads, in which the field magnets are excited partly by rectified or commuted currents taken from separate armature coils, and partly by currents furnished by the commuted current from a small transformer, whose primary coil is placed in the main circuit.

Alternator, Compound. An alternating current dynamo-electric machine whose field magnets are compound-wound.

The current from the machine is commonly run through a series transformer whose secondary winding is connected with the field magnets through a commutator.

Alternator, Three-phase. An alternating-current dynamo capable of producing three-phase currents. Usually these three separate currents are 120° in phase with respect to each other, their algebraic sum at any instance being zero.

Aluminum. A soft, ductile, weak, malleable metal of white color approaching silver, but with a bluish cast. Does not readily oxidize. Melts at a low temperature. Cannot readily be welded, or brazed or soldered. Very electropositive, and is eaten away in presence of salts and other metals. Atomic weight 27.1. Specific gravity 2.6 to 2.7. The lightest of all useful metals next to magnesium. Expands greatly with increasing temperature. For equal conductivity, aluminum has about twice the size, but one-half the weight of copper. Tenacity about one-third that of wrought-iron. (See page 14.)

Amalgam. A combining of a metal with mercury. Tin is very commonly used for this purpose.

American Twist Joint. A joint between two conducting wires in which each end is twisted around the other.

American Wire Gauge. The name generally given to the Brown and Sharpe wire gauge, in which the largest wire, No. 0000, has a diameter of .46″, the wire No. 36 .005″, and all other diameters are in geometrical progression. (See page 21.)

Ammeter. A form of galvanometer in which the value of the current is measured directly in amperes. (See Galvanometer.)

An ampere-meter or ammeter is a commercial form of galvanometer in which the deflections of a magnetic needle are calibrated or valued in amperes. As a rule the coils of wire in an ammeter are of lower resistance than in a voltmeter. The magnetic needle is deflected from its zero position by the field produced by the current whose strength in amperes is to be measured. This needle is held in the zero position by the action of a magnetic field, either of a permanent or an electromagnet, by the action of a spring, or by a weight under the influence of gravity. There thus exist a variety of ammeters, viz.: permanent-magnet ammeters, electromagnetic ammeters, spring ammeters and gravity ammeters.

Amperage. The number of amperes passing in a circuit in a given time.

Ampere. The practical unit of electric current. A rate of flow of electricity transmitting one coulomb per second. The current of electricity which would pass through a circuit whose resistance is one ohm, under an electromotive force of one volt. A current of such a strength as will deposit 1.118 milligrammes of silver per second from a specifically prepared solution of silver nitrate. (See International Ampere.)

Ampere-hour. A unit of electrical quantity equal to the quantity of electricity conveyed by one ampere flowing for one hour. A quantity of electricity equal to 3600 coulombs.

Ampere-hour Meter. An instrument giving the total time integral of the amperes.

Ampere-meter. An ammeter.

Ampere-second. A unit of electric quantity equal to the quantity of electricity conveyed by one ampere flowing for one second. A coulomb.

Ampere-turn. A unit of magneto-motive force equal to that produced by one ampere flowing around a single turn of wire.

Ampere-volt. A word sometimes used for volt-ampere or watt.

Amplitude of Vibration or Wave. The extent of the excursion of a simply vibrating particle on either side of its vibrating point or point of rest.

Anchor Log. A log partially buried in the ground and serving as an anchor for a telegraphic pole.

Anchor Strain-ear. In an overhead trolley system a trolley ear or insulator employed for anchoring the trolley wire, or maintaining it taut, so as to ensure good and continuous contact with the trolley wheel.

Anchored Filament. An incandescent lamp filament supported as its centre to prevent injury to it by excessive vibration.

Angle of Declination. The angle which measures the deviation of the magnetic needle to the east or west of the true geographical north. The angle of variation of a magnetic needle.

Angle of Dip. The angle which a magnetic needle, free to move in both a vertical and horizontal plane, makes with the horizontal line passing through its point of support. The angle of inclination of a magnetic needle.

Angle of Inclination. The angle of dip.

Angle of Lag of Current. An angle whose tangent is equal to the ratio of the inductive to the ohmic resistance in a circuit; whose cosine is equal to the ohmic resistance divided by the impedance of a circuit; and whose cosine is the ratio of the real to the apparent power in an alternating-current circuit.

Angle of Lead. The forward angular deviation from the normal position which must be given to the collecting brushes on the commutator of a continuous-current generator in order to obtain quiet commutation.

Angular Velocity. The velocity of a point moving relatively to a centre of rotation or to some selected point, and usually measured in degrees per second, or in radians per second. In a sinusoidal current circuit the product of 6.2832 and the frequency of the current.

Anion. The electro-negative ion or radical of a molecule.

Annunciator Drop. An annunciator signal whose dropping indicates the closing or opening of the circuit of a particular electromagnet connected therewith.

Annunciator Wire. A class of insulated wire prepared for use in annunciator circuits (see page 94).

Anode. The conductor or plate of a decomposition cell connected with the positive terminal of a battery or other electric source. The terminal of an electric source out of which the current flows into the electrolyte of a decomposing cell or voltameter. In an electrolytic cell, bath, or receptive device, the terminal at which the current enters, as distinguished from the cathode, at which the current leaves.

Anodic Currents. In a polarized voltaic couple immersed in acidulated water, the electric currents produced by the agitation of the plate connected with the anode.

Anomalous Magnet. A magnet possessing more than two free poles.

Antenna. A vertical wire supported by a mast and grounded at its lower end through a spark gap. Used as an oscillator in sending wireless messages.

Anti-induction Telephone Cable. A telephone cable in which the conductors are so arranged as to neutralize the effects of induction produced by neighboring circuits. A telephone cable in which the effects of electrostatic induction from neighboring circuits is avoided by a metallic covering or sheathing that is grounded at suitable intervals.

Aperiodic Galvanometer. A galvanometer whose needle comes to rest without any oscillation. A dead-beat galvanometer.

Apparent Conductor-resistance. The impedance of a conductor which forms part of an alternating current containing both resistance and reactance.

Apparent Efficiency. The efficiency of a generator, motor, or other apparatus in an alternating-current circuit which equals the ratio of net power output to volt-ampere input.

Apparent Electromotive Force. The E.M.F. apparently acting in a circuit as measured by the drop of pressure due to the resistance of the circuit and the current strength passing through it.

Apparent Power. In an alternating-current circuit, the apparent watts, or the product obtained by multiplying the volts by the amperes, as read directly from a voltmeter and ammeter.

Apparent Reluctance. The reluctance of a magnetic circuit, or portion thereof, under the influence of a complex of such superposed magnetic fluxes as may practically be developed, as distinguished from its reluctance under a single magnetizing force.

Apparent Resistance. The impedance in an alternating-current circuit or portion thereof.

Apparent Watts. The apparent power in an alternating-current circuit as distinguished from the real power.

Arc. A voltaic arc. A portion of a circle or other plane conic section.

Arc-lamp, Electric. The arc lamp is an electrical apparatus in which an electric arc is struck and maintained between two or more electrodes, giving a brilliant illumination, the color and intensity of which depends upon the composition and diameter of the electrodes, the kind of current supplied and the watts consumed.

Arc-lamp, Enclosed. An arc lamp in which the arc and exposed carbons are completely enclosed in a small inner globe which is nearly airtight. Used in both alternating and direct current circuits.

Arc-lamp, Flaming. See Flaming Arc Lamp.

Arc-lamp Compensator. A reactive or chocking coil, placed in the circuit of a lamp for the purpose of automatically regulating the amount of current passing through the lamp.

Arc-light Regulator. A device, generally automatic, for maintaining the carbons of an arc-lamp a constant distance apart during the operation of the lamp.

Arc, Voltaic. The brilliant light which appears between the electrodes or terminals, generally of carbon, of a sufficiently powerful source of electricity, when separated a short distance from each other.

The source of light of the electric arc lamp. It is called the voltaic arc because it was first obtained by the use of the battery invented by Volta. The term arc was given to it from the shape of the luminous bow or arc formed between the carbons.

To form the voltaic arc the carbon electrodes are first placed in contact and then gradually separated. A brilliant arc of flame is formed between them, which consists mainly of volatilized carbon. The electrodes are consumed, first, by actual combination with the oxygen of the air; and, second, by volatilization under the combined influence of the electric current and the intense heat.

As a result of the formation of the arc, a crater is formed at the end of the positive carbon, and appears to mark the point out of which the greater part of the current flows.

The crater is due to the greater volatilization of the electrode at this point than elsewhere. It marks the position of highest temperature of the electrodes, and is the main source of the light of the arc. When, therefore, the voltaic arc is employed for the purpose of illumination with vertically opposed carbons, the positive carbon should be made the upper carbon, so that the focus of greatest intensity of the light may be favorably situated for illumination of the space below the lamp. When, however, it is desired to illumine the side of a building above an arc lamp, the lower carbon should be made positive.

The positive carbon is consumed about twice as rapidly as the negative, both because the negative oxygen attacks the points of the positive carbon, and because the positive carbon suffers the most rapid volatilization.

Armature. A mass of iron or other magnetizable material placed on or near the poles of a magnet. The armature of a dynamo-electric machine.

Armature Bars. Heavy copper bars of rectangular or trapezoidal cross-section or of imbricated rectangular strips, or of rectangular bars of compressed stranded wire, or of special forgings, employed on large drum armatures in place of the ordinary wire windings. Heavy conductors employed for armature windings.

Armature Binding Wires. Coils of wire bound on the outside of the armature wires for the purpose of preventing their separating from the armature core by centrifugal force. (See page 80.)

Armature Bore. The space between the pole-pieces of a dynamo or motor provided for the rotation of the armature.

Armature Core-discs. The thin discs of sheet-iron that form, when assembled, the laminated core of the armature of a dynamo or motor.

Armature Core of Dynamo. The mass of laminated iron on which the armature coils or conductors of a dynamo or motor are placed.

Electrical Dictionary

Armature Inductors. The bars, strips or coils placed on the dynamo armature core, in which electromotive forces are induced by rotation.

Armature of Dynamo. Coils of insulated wire together with the iron core on or around which such coils are wound. That part of a dynamo in which useful differences of potential or useful currents are generated. Generally that part of a dynamo which is revolved between the pole-pieces of the field magnets. That member of a dynamo in which the magnetic flux is caused to successively fill and empty the coils and thereby generate E.M.F.'s.

Armature Reaction. The reactive magnetic influence produced by the current in the armature of a dynamo or motor, on the magnetic circuit of the machine.

Armature Slots. Slots provided in an armature core for the reception of the armature coils.

Armature Spider. A metal frame-work keyed to the armature shaft, and provided with radial arms for firmly holding the armature core.

Armature Stamping. Stampings of soft sheet iron intended for the core discs of a laminated armature core.

Armature Teeth. The armature core projections between armature slots.

Armature Varnish. An insulating varnish sometimes applied to armature windings for the purpose of increasing their powers of resisting moisture and friction.

Armor of Cable. The protecting sheathing or metallic covering of a submarine or other electric cable. (See page 149.)

Arrester Plate of Lightning Protector. The ground-connected plate of a comb lightning-arrester.

Artificial Cable. A circuit containing associated resistance and capacity, and employed in a system of duplex submarine telegraphy corresponding to the artificial line in duplex aerial line telegraphy.

Asbestos. A hydrous silicate of magnesia, i. e., silicate of magnesia combined with water. A fire-proofing material sometimes used by itself or in connection with other material for insulating purposes.

Astatic. Devoid of magnetic directive power.

Astatic Couple. Two magnets of equal strength so placed one above the other in a vertical plane as completely to neutralize each other's effects.

Astatic Galvanometer. A galvanometer provided with an astatic needle or circuit.

Astatic Needle. A compound magnetic needle of great sensibility, possessing little or no directive power. An astatic needle consisting of two separate needles rigidly connected and placed parallel one directly over the other with opposite poles opposed.

Asynchronism. Devoid of synchronism.

Asynchronous Alternating-Current Motor. A motor whose speed is not synchronous with that of its driving generator, both machines having the same number of poles.

Atonic Interrupter. This is a mechanical form of interrupter that can be adjusted to operate at any frequency within very wide limits. It is actuated by a magnetic core.

Attachment Plug. A plug provided for insertion in a screw socket or spring jack, for the ready connection of a lamp or other receptive device to a circuit.

Attraction, Electro-Magnetic. The mutual attraction of the unlike poles of electro-magnets.

Attraction, Electrostatic. The mutual attraction exerted between unlike electric charges, or bodies possessing unlike electric charges.

Auto Balancer. An auto transformer for equalizing the load or voltage when a three, or more, wire circuit is derived from a two-wire circuit.

Auto-exciting. Self-exciting.

Autographic Telegraphy. Facsimile telegraphy. A writing telegraph.

Automatic Repeater. A telegraphic repeater which is automatically operated, in contradistinction to a manual repeater which is operated or controlled by hand.

Automatic Circuit-breaker. A device for automatically opening a circuit when the current passing through it is excessive.

Automatic Contact-breaker. A device for causing an electric current to rapidly make and break its own circuit.

Automatic Electric Bell. A trembling or vibrating bell. An automatic electric alarm-bell.

Automatic Switch. A switch which is automatically opened or closed on the occurrence of certain predetermined events. In double-current telegraphy an electro-magnetic switch which enables the distant station to stop the sending operator at the home station.

Auto-starter. A self-starting mechanism. A self-starting ink-writer. A self-starting motor.

Auto-transformer. A one-coil transformer consisting of a choking coil connected across a pair of alternating-current mains, and so arranged that a current or pressure differing from that supplied by the mains can be obtained from it by tapping the coil at different points. Called also a compensator. A transformer in which a part of the primary winding is used as the secondary winding, or conversely.

Average Efficiency of Motor. The efficiency of an electric motor based on its average or mean load. The ratio of all the work that a motor delivers in a given time to the electric energy it has absorbed in that time.

Axes of Co-ordinates. A vertical and a horizontal line, usually intersecting each other at right angles, and called respectively the axes of ordinates and abscissas, from which the ordinates and abscissas are measured.

Axis of Abscissae or Abscissas. The horizontal line in the axes of co-ordinates.

Axis of Magnetic Needle. A straight line drawn through a magnetic needle, and joining its poles.

Axis of Ordinates. The vertical line in the axes of co-ordinates.

Azimuth and Range Telegraph. On a war-ship a combined telegraph to the guns of the azimuth and range of a target.

B.

$\mathfrak{B}$ A symbol for magnetic flux-density, usually expressed in C.G.S. units per normal square centimetre.

B.A. Ohm. The British Association ohm. The resistance of a column of mercury one square millimeter in area of normal cross-section, and 104.9 centimetres in length, at the temperature of zero centigrade.

B.A. Unit. The British Association unit of resistance or ohm.

B. & S. G. A contraction for Brown and Sharpe's wire gauge.

B.T.U. A contraction for British thermal unit. A contraction for Board of Trade unit.

B.W.G. A contraction for Birmingham wire gauge.

Back Ampere-turns. Ampere-turns on a dynamo armature which tend to oppose the flux produced by the field magnets.

Back Electromotive Force. A term sometimes used for counter-electromotive force.

Back Induction. An induction opposed to the field and tending to weaken or neutralize it.

Back Pitch. The backward pitch of the armature windings.

Back-turns of Armature. Those turns on an armature whose current tends to demagnetize the field. The back ampere-turns.

Balanced Circuit. A telephonic, telegraphic or other circuit which has been so erected and adjusted as to be free from mutual inductive disturbances from neighboring circuits.

Electrical Dictionary

Balanced Load. A load which is symmetrically divided between two or more generating units, as in the three-wire, five-wire multiple, or polyphase systems of distribution.

Balanced Resistance. A resistance so placed in a bridge or balance as to be balanced by the remaining resistances in the bridge.

Balancing Coil of Armature. An auxiliary field-winding in series with an armature, and having its magnetomotive force equal and opposite to that of the armature current, so that their total magnetic effect upon the field is zero, and the field flux remains unchanged at all loads.

Balancing Relay. A differentially wound relay.

Ballistic Galvanometer. A galvanometer designed to measure the total quantity of electricity in a discharge lasting for a brief interval, as, for example, the current caused by the discharge of a condenser. A galvanometer, in which the movable part is as little damped as possible, suitable for measuring electric charges or discharges, and usually adjusted to have a long period of vibration or slow swing.

Bank of Lamps. A group of electric lamps collected together in a common structure, usually for the purpose of obtaining a load.

Bar Armature. An armature whose conductors are formed of bars.

Barretter. A special and very sensitive form of thermal detector of Marconi signals. Used as a receiver for wireless messages. It consists of a fine platinum wire about .00006″ in diameter and a few hundredths of an inch long, connected in series with a small source of E.M.F. and a telephone receiver. Designed by Professor R. A. Fessenden.

Barrow-reel. A reel supported on a barrow for convenience in paying out an overhead conductor during its installation.

Battery. A name frequently used for an electric-battery.

Battery, Dry. A number of separate dry voltaic cells combined so as to act as a single source.

Battery, Closed-circuit. A voltaic battery which may be kept constantly on close-circuit without serious polarization.

The gravity battery is a closed circuit battery. As employed for use on most telegraph lines, it is maintained on a closed circuit. When an operator wishes to use the line he opens his switch, thus breaking the circuits and calling his correspondent. Such batteries should not polarize.

Battery, Electric. A general name applied to the combination, as a single source of a number of separate electric sources.

Battery, Galvanic. Two or more separate voltaic cells so arranged as to form a single source.

Battery Gauge. A form of portable galvanometer suitable for ordinary battery testing work.

Battery Jar. A jar provided for holding the electrolyte of each of the separate cells of a primary or secondary battery.

Battery, Open-circuit. A voltaic battery which is normally on open-circuit, and which is used continuously only for comparatively small durations of time in closed-circuit.

Battery Pole-changer. A form of transmitter employed in duplex telegraphy for readily reversing the direction of the main battery so as to send signals to the line.

Battery, Secondary. The combination of a number of separate secondary or storage cells, so as to form a single electric source.

Battery Solution. The exciting liquid or electrolyte of a primary or secondary cell.

Battery, Storage. A number of separate storage cells connected so as to form a single electric source.

Battle Circuit. A circuit on a warship, connected with the conning tower and provided for use during action.

Beaded Cable. A form of cable employed for high-tension transmission, provided with a sheathing of strung porcelain beads.

Beg-ohms. One billion ohms, or one thousand megohms.

Belt Circuit. A series lighting circuit extending in the form of a wide loop, belt, or circle, as opposed to a circuit formed of two closely associated parallel wires.

Belt, Electric. A belt suitably shaped so as to be capable of being worn on the body, consisting either of imaginary or real voltaic or thermo-electric couples, and employed for its alleged therapeutic effects.

Bicro. A prefix for one-billionth, one thousand millionth, or 10^9.

Bifilar Suspension. Suspension by means of parallel vertical wires or fibres as distinguished from suspension by a single wire or fibre.

Bifilar Winding. The method of winding employed in resistance coils to obviate the effects of self-induction, in which the wire, instead of being wound in one continuous length, is doubled on itself before winding.

Bight of Cable. A single loop or bend of cable.

Bimetallic Wire. A compound telephone or telegraph wire consisting of a steel core and a copper envelope, suitable for long-span overhead-construction.

Binding Post. A metallic binding screw, rigidly fixed to some apparatus or support, and employed for conveniently making firm electric connections.

Binding Wire. Coils of wire, wound on the outside of the armature coils and at right angles thereto, to prevent the loosening of the armature coils during rotation by centrifugal force. (See page 80.)

Bioscopy, Electric. The determination of the presence of life or death by the passage of electricity through the nerves or muscles.

Bipolar. Having two poles.

Bipolar Armature. An armature suitable for use in a bipolar field.

Bipolar Armature-winding. Any armature winding suitable for use in a bipolar field.

Bipolar Dynamo-electric Machine. A dynamo-electric machine with a bipolar field.

Bird Cage, Electric. A bird-cage-shaped wire screen employed by Hertz in his investigations of the propagation of electro-magnetic waves for screening the spark micrometer.

Birmingham Wire Gauge. An English wire gauge. (See page 22.)

Black Lead. Plumbago or graphite.

Blasting, Electric. The electric ignition of powder or other explosive material in a blast.

Bleaching, Electric. A bleaching process in which the bleaching agents are liberated as required by electrolytic decomposition.

Block Rate. Method of charging for electric service at different successive rates per kilowatt-hour consumed, each successive rate applying only to a corresponding successive block or quantity of the total current purchased during the period covered; as an example, during each month 10 kilowatt-hours or less at 15 cents per kilowatt-hour. The next 10 kilowatt-hours over the first are charged for at 12 cents per kilowatt-hour. All current in excess of the foregoing 20 kilowatt-hours is charged for at 10 cents per kilowatt-hour.

Blow. To melt or fuse a safety fuse.

Blowing a Fuse. The fusion or volatilization of a fuse wire or safety strip by the current passing through it.

Blowing Point of Fuse. The current strength at which a fuse blows or melts.

Board of Trade Unit. A unit of electric supply, or the energy contained in a current of 1,000 amperes flowing for one hour under a pressure of one volt. A kilowatt-hour.

Bobbin, Electric. A coil of insulated wire suitable for the passage of an electric current for any purpose, as, for example, energizing an electro-magnet.

Bolt. A lightning discharge.

Bond, Electric Rail. See Rail Bond, Electric. (See page 67.)

Booster. A dynamo, inserted in series in a special feeder or group of feeders in a distribution system, for the purpose of raising the pressure of that feeder or group of feeders above that of the rest of the system.

Bore, Armature. The space provided between the pole pieces of a dynamo or motor for the rotation of the armature.

Boucherizing. A process for preserving wooden telegraph poles, or railroad sleepers, by injecting a solution of copper sulphate into the pores of the wood.

Bound Charge. The condition of a charge on a conductor placed near another conductor, but separated from it by a medium through which electrostatic induction can take place.

Bracket-arm. An arm supported by a bracket for carrying a line insulator.

Brake, Prony. A mechanical device for measuring the power of a driving shaft.

Braided Wire. A wire covered with a braiding of insulating material.

Branch Block. A porcelain block provided with suitable grooves in which the terminals or conductors are placed for connecting a pair of branch wires to the mains.

Branch Circuits. Additional circuits provided at points of a circuit where the current branches or divides, part of the current flowing through the branch, and the remainder flowing through the original circuit. A shunt circuit.

Branch Conductor. A conductor placed in a branch or shunt circuit. A smaller or sub-conductor tapping a main.

Branch Cut-out. A safety fuse or cutout, inserted between a pair of branch wires and the mains supplying them.

Brass. An alloy of copper and zinc.

Break-down Switch. A panel switch employed in small three-wire systems, for connecting the positive and negative bus-bars so as to convert the system into a two-wire system, and thus, in case of a break-down, to permit the system to be supplied with current from a single dynamo.

Break, Mercury. A form of circuit breaker operated by the removal of a conductor from the mercury surface.

Mercury breaks assume a variety of forms. One end of the circuit is connected with the mercury, and the other with the conductor.

Breaking Down of Insulation. The failure of an insulating material, as evidence by the disruptive passage of an electric discharge through it.

Breast Plate. The breast support for the microphone transmitter of a central telephone station operator.

Bridge Arms. The arms of an electric bridge or balance.

Bridge Duplex. The bridge method of duplex telegraphy, as distinguished from the differential method.

Bridge, Electric. A device whereby an unknown electric resistance is readily measured. A device for measuring an unknown resistance by comparison with two fixed resistances and an adjustable resistance.

Bridge-wire. The wire in a Wheatstone's Bridge in which the galvanometer is inserted.

Bridging Coils. In telephony, coils which are connected across a telephone circuit, as distinguished from coils placed in series in the circuit.

Bridging Relay. In telephony or telegraphy a relay which is connected in shunt across a circuit instead of in series.

Britannia Joint. A telegraphic or telephonic joint in which the ends of the wires are laid side-by-side bound together, and subsequently soldered.

Bronze. An alloy of copper and tin.

Brush-and-Spray Discharge. A streaming form of high-potential discharge possessing the appearance of a spray of silvery white sparks, or of a branch of thin silvery sheets around a powerful brush, obtained by increasing the frequency of the alternations.

Brush Discharge. The faintly luminous discharge which takes place from a positive charged pointed conductor.

Brush Rocker. In a dynamo or motor any device for shifting the position of the brushes on the commutator cylinder.

Brushes of Dynamo-electric Machines. Strips of metal bundles of wire or wire gauze, slit plates of metal, or plates of carbon, that bear on the commutator cylinder of a dynamo, and carry off the current generated.

Bucking. A term employed in the operation of street-railway passenger cars for a sudden stopping of the car as if by a collision, due to opposition between two motors.

Bug. A term employed in quadruplex telegraphy to designate any fault in the operation of the apparatus. Generally, a fault in the operation of any electric apparatus. A particular fault or difficulty in quadruplex telegraphy consisting of an interference between the A and B-sides.

"Building-up" of Dynamo. The action whereby a dynamo-electric machine rapidly reaches its maximum E.M.F. after starting.

"Built-up" Magnet. A composite permanent magnet.

Bulb, Lamp. The chamber or globe in which the filament of an incandescent electric lamp is placed.

The chamber or globe of a lamp must be of such construction as to enable the high vacuum necessary to the operation of the lamp to be maintained.

Bunched Cable. A cable containing more than a single wire or conductor.

Burglar-alarm, Electric. An electric device for automatically announcing the opening of a door, window, or safe, or the passage of a person through a hallway, or on a stairway.

Burglar-alarm Matting. A matting provided with a number of invisible contacts connected with an alarm bell, whose circuits are closed by treading on the matting.

Burn-out. The destruction of an armature, or any part of an electric apparatus, by the passage of an excessive current due to short-circuit or other cause.

Burner, Electric. A gas-burner that is capable of being electrically lighted.

Bus. A word generally used instead of omnibus. Heavy copper bar conductors usually attached to switch-boards, etc.

Bus-bars. Heavy bars of conducting metal connected directly to the poles of one or more dynamo-electric machines, and, therefore, receiving the entire current produced by the machines.

Busy Test. A simple test whereby a telephone operator at a multiple switchboard can readily tell whether any wire or circuit connected with the switchboard is or is not in use at any moment of time.

Butt Joint. An end-to-end joint. A joint effected in wires by placing the wires end on end subsequently soldering or welding them.

Buzzer, Electric. A call, not as loud as that of an electric bell, employing a humming sound by the use of a sufficiently rapid automatic contact-breaker. A telephone receiver for Morse circuits employing a vibrating contact key.

C.

C. A contraction for Centigrade.

C. A symbol used for capacity. Farad.

The defining equation is $C=\frac{Q}{E}$

The same symbol is often used for current.

Electrical Dictionary

C.E.M.F. A contraction for counter electromotive force.

c.c. A contraction for cubic centimetre, the C.G.S. unit of volume.

cm. An abbreviation for centimetre, the C.G.S. unit of length.

C.P. A contraction for candle-power.

C^2R. Activity. The I^2R activity, which see.

C^2R. Loss. The loss of energy in a conductor due to the ohmic resistance and the current strength. (See page 19.)

C.G.S. Units. The centimetre-gramme-second units.

Cable. An electric cable. A message transmitted by means of an electric cable.

Cable Box. A box provided for the reception and protection of a cable head.

Cable Casing. The metallic sheathing of a cable.

Cable Clip. A term sometimes used for cable hanger.

Cable Core. The insulated conducting wires of an electric cable. The electrically essential portion of a cable as distinguished from its sheath or protection.

Cable Currents. Various currents that exist in a submarine cable and interfere with the testing, consisting of earth currents, electrostatic charge and discharge currents, and polarization currents due to a fault or break. A current flowing through a cable in the absence of any impressed E.M.F. The current which tends to flow in a broken cable from the exposed copper conductor at the fracture to the iron sheathing through the apparatus at the station.

Cable Drum. In cable machinery, a drum on which cable is wound for coiling, shipping, laying, or turning over. A drum or reel on which cable is wound for transport.

Cable, Duplex. A conductor consisting of two separate cables placed parallel to each other.

The duplex cable is used especially in the alternating current system.

Cable, Electric. A combination of an extended length of a single insulated electric conductor, or of two or more separate insulated electric conductors, covered externally with a metallic sheathing or armor.

Cable Fault. Any failure in the proper working of a cable due either to a total or partial fracture of the cable or to a heavy electric leakage.

Cablegram. A telegraph message received by cable

Cable Grip. The grip provided for holding the end of an underground cable while it is being drawn into a duct. In a cable road the grip by means of which a car is driven by the moving cable.

Cable Head. A rectangular board provided with binding posts and fuse wires for the purpose of receiving the wires of overhead lines where they enter a cable.

Cable House. A hut provided for securing and protecting the end of a submarine cable when it is landed.

Cable Lead. A lead formed of a cable of several stranded conductors, as distinguished from a lead containing a single conductor.

Cable Rack. A rack placed at the back of a multiple telephone switchboard for supporting the cabled switchboard conductors and providing ready access to the same.

Cable, Submarine. A cable designed for use under water. (See page 164.)

Cable Telegraph. A general term including all the apparatus employed in cable telegraphy

Cable Terminal. A water-tight covering provided at the free end of a telephone cable to prevent injury to the cable's insulation by the moisture of the air.

Cable Transformer. An alternating-current transformer in which the primary and secondary conductors have the form of a cable overlaid by an iron sheath or magnetic circuit.

Cable Vault. A vault provided in a building where cables enter from underground conduits, and where the cables are opened and connected to fusible plugs or safety catches.

Cable, Underground. An electric cable placed underground. See index.

Cable Well. A cable tank.

Cage Lightning-Protector. A term sometimes employed for a lightning protector, consisting of wires in the form of a cage surrounding the body to be protected.

Calculagraph. A machine employed in long-distance telephony for registering the time during which the use of a line by a subscriber continues.

Calling Plug. That plug of a pair of plugs, at a central telephone switchboard, which is inserted in the jack of the subscriber wanted and through which that subscriber is called up.

Call Signal. In telegraphy, the signal or group of signals indicating the particular station called.

Call Wire. A speaking wire. A wire connecting two telephone exchanges, for the purpose of transmitting instructions, as distinguished from a wire employed for establishing communication between subscribers. A wire employed for calling the attention of a central-station operator by a subscriber, as distinguished from the wires through which he communicates with other subscribers.

Calorie. A heat unit. The quantity of heat required to raise 1 gramme of water 1° centigrade.

Calorimeter, Electric. An instrument for measuring the heat developed in a given time in any conductor, by an electric current.

Candle. A unit of photometric intensity. The photometric intensity which would be produced by a standard candle burning at the rate of two grains per minute.

Candle-foot. A unit of illumination equal to that normally produced by a standard British candle, at a distance of one foot, and sometimes called a lux.

Candle-Lumen. The total flux of light from a source is equal to its mean spherical intensity multiplied by 4π. The unit of flux is called the lumen. A lumen is the $\frac{1}{4\pi}$th part of the total flux of light emitted by a source having a mean spherical intensity of one candle-power. A hefner-lumen is 0.90 lumen.

Candle-power. The intensity of light emitted by a luminous body estimated in standard candles. The photometric intensity of one standard candle. The hefner = 0.9 this unit.

Caoutchouc. A resinous substance possessing high powers of electric insulating, obtained from the milky juice of certain tropical trees. India rubber.

Cap Wire. An overhead wire carried on the summit of a pole, as distinguished from an overhead wire carried on a cross-arm.

Capability, Electric, of a Dynamo. The ratio of the square of the E.M.F to the brushes, divided by the internal resistance of the machine.

Capacity Circuit. A circuit containing capacity but no inductance.

Capacity Current of Cable. The current in a cable due to its capacity. The charging or discharging current in a cable.

Capacity, Electrostatic. The quantity of electricity which must be imparted to a given body or conductor as a charge, in order to raise its potential a certain amount. (See Potential, Electric)

The electrostatic capacity of a conductor is not unlike the capacity of a vessel filled with a liquid or gas. A certain quantity of liquid will fill a given vessel to a level dependent on the size or capacity of the vessel. In the same manner a given quantity of electricity will produce, in a conductor or condenser, a certain difference of electric level, or difference of potential, dependent on the electrical capacity of the conductor or condenser.

Electrical Dictionary

In the same manner, the smaller the capacity of a conductor, the smaller is the charge required to raise it to a given potential, or the higher the potential a given charge will raise it.

The capacity C, of a conductor or condenser, is therefore directly proportional to the charge Q, and inversely proportional to the potential E; or,

$$C = \frac{Q}{E}$$

From which we obtain $Q = CE$.

The quantity of electricity required to charge a conductor or condenser to a given potential is equal to the capacity of the conductor or condenser multiplied by the potential through which it is raised.

Capacity, Electrostatic, Unit of. Such a capacity of a conductor or condenser that an electromotive force of one volt will charge it with a quantity of electricity equal to one coulomb.

The farad. (See Farad.)

Capacity Factor. Ratio of the station output in kilowatt-hours to the maximum capacity of the station in kilowatts.

Capacity Load. The apparent load or current of a high-tension generator due to the capacity of the distributing conductors as distinguished from the load or current usefully distributed.

Capacity of Cable. The quantity of electricity required to raise a given length of cable to a given potential, divided by the potential. In a multiple cable, the amount of charge at unit potential which any single conductor will take up, the rest of the conductors being grounded. The ability of a conducting wire or cable to permit a certain quantity of electricity to be passed into it before acquiring a certain potential.

Capacity of Line. The ability of a line to act as a condenser, and, therefore, like it, to possess capacity.

Capacity Pressure. In a condenser connected with a source of alternating currents, a pressure in phase with the condenser current. A pressure due to a capacity. The pressure at the terminals of a condenser.

Capacity Reactance. The reactance of a condenser due to its capacity. The condensance.

Capacity, Specific Inductive. See Specific Inductive Capacity.

Capillary Electrometer. An electrometer in which difference of potential is measured by the movements of a drop of sulphuric acid in a tube filled with mercury.

Car-brake, Electric. A car-brake that is operated by the electric current produced by the motor acting as a generator when the current is turned off and the car is rapidly moving.

Car Controller. A device placed at each end of the platform of a trolley car, under the control of the motorman for starting, stopping, reversing or changing the velocity of a trolley car. A series-parallel car-controller.

Car-heater, Electric. An electric heater consisting essentially of suitably supported coils of insulated wire traversed by an electric current.

Carbon. An elementary substance which occurs naturally in three distinct allotropic forms: graphite, charcoal and the diamond.

Carbon Arc. A voltaic arc formed between carbon electrodes.

Carbon Holder. A device employed in an arc lamp for supporting the lower or negative carbon.

Carbon Rheostat. An adjustable resistance formed of carbon plates or powder whose resistance can be varied by pressure.

Carcel. A French photometric standard of light. The light emitted by a lamp of definite dimensions burning 42 grammes of Colza oil in an hour, with a flame 40 millimetres in height.

Cardew Voltmeter. A voltmeter whose indications are obtained by the expansion of a long fine wire by the passage through it of the current to be measured.

Carrying Capacity. The maximum current strength that any conductor can safely transmit. (See page 18.)

Cascade Connection. A term sometimes employed for series connection.

Casings. Grooves or panelled channels for carrying wires in a house.

Catenary Curve. The curve described by the sagging of a wire, under its own weight, when stretched between two points of support.

Catenary Trolley Construction. A trolley wire that is suspended at frequent intervals from a messenger wire. (See page 77.)

Cathode. The conductor or plate of an electro-decomposition cell connected with the negative terminal of a battery or other electric source. The terminal of an electric source into which the current flows from the electrolyte of a decomposition cell or voltameter. The electrode of a bath, tube, body, or device by which the current leaves the same. The negative electrode.

Cathode Rays. Radiation emitted from the cathode or negative electrode of a Crookes or X-ray tube.

Cautery, Electric. The application to the human body of variously shaped platinum wires, heated to incandescence by the electric current, for removing diseased growths, or for stopping hemorrhages.

Ceiling Board. An arc-light hanger board.

Cell, Electrolytic. A cell or vessel containing an electrolyte, in which electrolysis is carried on.

An electrolytic cell is called a voltameter when the value of the current passing is deduced from the weight of the metal deposited.

Cell, Voltaic. (See Voltaic Cell.)

Cell of Primary or Secondary Battery. A battery jar of a primary or secondary battery containing a single couple and its electrolyte.

Centigramme. The hundredth of a gramme; or, 0.1543 grain avoirdupois.

Centimeter. The hundredth of a metre; or, 0.3937 inch.

Centimeter-Gramme-Second System. A system based on the centimeter as the unit length, the gramme as the unit of mass, and the second at the unit of time.

Center of Distribution. In a system of incandescent distribution any point at which the supply current is branched or radially disturbed to mains, to submains, or to translating devices.

Change-over Switch. A switch provided in a central station for transferring a working circuit from one dynamo to another, or from one battery of dynamos to another.

Characteristic Curve. A diagram in which a curve is employed to represent the relation of certain varying values. A curve indicating the characteristic properties of a dynamo-electric machine under various phases of operation. A curve indicating the electromotive force of a generator, as a variable dependent on the excitation.

Charge Current on Telegraphic Line. The current produced by the initial rush of electricity into a telegraph line on the closing of the circuit.

Charge Bound. The condition of an electric charge on a conductor placed near another conductor, but separated from it by a medium through which electrostatic induction can take place.

Charge, Electric. The quantity of electricity that exists on the surface of an insulated electrified conductor.

Charging Current. The current employed in charging a storage battery or accumulator.

Chatterton's Compound. An insulating compound for cementing together the alternate coatings of gutta-percha employed on a cable conductor, or for filling up the space between the stranded conductors.

Chemical Battery. A name sometimes given to a voltaic telegraph battery as distinguished from a dynamo.

Chemical Equivalent. The quotient obtained by dividing the atomic weight of an elementary substance by its atomicity. The ratio between the quantity of an element and the quantity of hydrogen it is capable of replacing. The quantity of an elementary substance that is capable of combining with or replacing one atom of hydrogen.

Choke Coil. A reactance used in connection with lightning arresters and placed in series with the line to be protected.

Choking Coil. A coil of wire so wound on a core of iron as to possess high self-induction when used on alternating-current circuits. (See Reactance Coils.)

Chronograph, Electric. An electric apparatus for automatically measuring and registering small intervals of time.

Circuit Breaker. Any device for opening or breaking a circuit.

Circuit, Electric. The path in which electricity circulates or passes from a given point, around or through a conducting path, back again to its starting point.

All simple circuits consist of the following parts, viz:

(1) Of an electric source ,which may be a voltaic battery, a thermopile, a dynamo-electric machine, or any other means for producing electricity.

(2) Of leads or conductors for carrying the electricity out from the source, through whatever apparatus is placed in the line, and back again to the source.

(3) Various electro-receptive devices, such as electro-magnets, electrolytic baths, electric motors, electric heaters, etc., through which passes the current by which they are actuated or operated.

Circuit Indicator. A rough form of galvanometer employed to indicate the presence and direction of a current in a circuit, and, in some cases, to roughly indicate its strength.

Circuit, Multiple. A compound circuit in which a number of separate sources or separate electro-receptive devices, or both, have all their positive poles connected to a single positive lead or conductor, and all their negative poles to a single negative lead or conductor.

Circuit, Multiple-Arc. A term often used for multiple circuit.

Circuit, Open. A broken circuit. A circuit, the conducting continuity of which is broken.

Circuit, Parallel. A name sometimes applied to circuits connected in multiple. (See Circuit, Multiple)

Circuit, Series. A compound circuit in which the separate sources, or the separate electro-receptive devices, or both, are so placed that the current produced in each, or passed through each, passes successively through the entire circuit from the first to the last.

Circuit, Short. A shunt or by-path of comparatively small resistance around the poles of an electric source, or around any portion of a circuit, by which so much of the current passes through the new path, as virtually to cut out the part of the circuit around which it is placed, and so prevent it from receiving an appreciable current.

Circuit, Shunt. A branch or additional circuit provided at any part of a circuit, through which the current branches or divides, part flowing through the original circuit, and part through the new branch.

Circular Mil. A unit of area employed in measuring the cross-section of wires, equal, approximately, to 0.7854 square mils. The area of a circle one mil in diameter. (See page 21.)

Circular Millage. The areas of cross-sections of wires or conductors expressed in circular mils.

Clearance. The gap space between the surface of a rotating armature and the opposed polar surface of the field magnets of a dynamo or motor.

Clearing-out Drops. Electro-magnetic drop-shutters placed in a telephone exchange in circuit with a pair of communicating subscribers, so that the falling of the shutter when they "ring off" indicates that the conversation is ended. Ring-off drops.

Clearing Signal. A ring-off signal. A signal in a telephone exchange to indicate that a telephonic conversation has ended.

Cleat, Electric. A suitable shaped piece of wood, porcelain, hard-rubber or other non-conducting material used for fastening and supporting electric conductors to ceilings and walls.

Clock Meter. An electric meter in which clock-work is employed.

Clockwise Motion. A rotary motion whose direction is the same as that of the hands of a clock, viewed from the face.

Closed-circuit Transformer. A term sometimes employed for closed iron-circuit transformer.

Closed-circuit Voltmeter. A voltmeter intended to be in permanent connection with the pressure it is designed to measure.

Closed-coil Winding. Any winding by which the armature coils are connected in closed circuit during the operation of the machine.

Closed Magnetic Circuit. A magnetic circuit which lies wholly in iron or other substance of high magnetic permeability.

Closet System of Parallel Distribution. A system of parallel distribution and house wiring in which the various receptive devices are collected in groups each of which is supplied with a separate and independent supply circuit back to the service; as distinguished from a tree system.

Coefficient of Expansion. The fractional increase in the length of a bar or rod, when heated from 32 to 33 degrees Fahr., or from 0 to 1 degree Cent.

Coefficient of Hysteresis. The work expended hysteretically in a cubic-centimetre of iron, or other magnetic substance, in a single cycle of unit magnetic flux density. The coefficient which multiplied by the volume of iron, the frequency of alternation, and the 1-6th power of the maximum flux density gives the hysteretic activity.

Coefficient of Inductance. A constant quantity such that, when multiplied by the current strength passing through any coil or circuit, will numerically represent the flux linkage with that coil or circuit due to that current. A term sometimes used for coefficient of self-induction. The ratio of the C.E.M.F. of self-induction in a coil or circuit to the time-rate-of-change of the inducing current.

Coefficient of Induction. A term sometimes used for coefficient of magnetic induction.

Coefficient of Mutual Inductance. The ratio of the electromotive force induced in a circuit to the rate-of-change of the inducing current in a magnetically associated circuit. The ratio of the total flux-linkage with a circuit proceeding from an associated inducing circuit, to the strength of current flowing in the latter.

Coefficient of Self-induction. Self-inductance. The ratio in any circuit of the flux induced by and linked with a current, to the strength of that current. The ratio in any circuit of the E.M.F. of self-induction to the rate-of-change of the current.

Coherer. A detector of electro-magnetic waves consisting of conducting particles forming a semi-conducting bridge between two electrodes

Coil, Electric. A convolution of insulated wire through which an electric current may be passed. A number of turns of wire, or a spool of wire, through which an electric current may be passed.

Electrical Dictionary

Coil, Induction. An apparatus consisting of two parallel coils of insulated wire employed for the production of currents by mutual induction.

A rapidly interrupted battery current, sent through a coil of wire called the primary coil, induces alternating currents in a coil of wire called the secondary coil.

As heretofore made, the primary coil consists of a few turns of a thick wire, and the secondary coil of many turns, often thousands, of fine wire. Such coils are generally called Ruhmkorff coils, from the name of a celebrated manufacturer of them.

Cold Light. Luminous radiation unaccompanied by obscure radiation. Radiation confined within the limits of the visible spectrum. The light of a fire-fly or glow-worm.

Collation. The repetition of a message or important parts of the same by an operator at a telegraph station who has received it over the line, to the transmitting operator at the sending station.

Collecting Rings for Alternators. Metallic rings connected with the terminals of the armature coils of an alternator on which brushes rest to carry off the alternating currents.

Collector, Electric. Devices employed for collecting electricity from a moving electric source.

Collector of Alternators. The collecting rings.

Comb Lightning-arrester. A form of lightning-arrester in which the line wires are connected to two metallic plates provided with serrations like the teeth of a comb, and placed near to another ground-connected plate, which may or may not be furnished with similar serrations.

"Come Along." A small portable vise capable of ready attachment to an aerial telegraph or telephone cable, and used in connection with a line dynamometer to pull up the wire to its proper tension.

Commercial Efficiency. The useful or available energy produced by any machine or apparatus divided by the total energy it absorbs.

Common Return. A return conductor common to several circuits.

Commutating Machine. A rotary transformer.

Commutation. The act of commuting or causing a number of electromotive forces or currents to take one and the same direction.

Commutation, Diameter of. In a dynamo-electric machine a diameter on the commutator cylinder on one side of which the difference of potential, produced by the movement of the coils through the magnetic field, tend to produce a current in a direction opposite to those on the other side.

That diameter on the commutator cylinder of an open-circuited armature that joins the points of contact of the collecting brushes.

Commutator. Any device for changing in one portion of a circuit the directions of electromotive forces or currents in another portion. A device for changing alternating into continuous currents, or vice versa.

Commutator Bar. One of the insulated segments of a commutator.

Commutator Coils. Coils wound around an armature core for the purpose of preventing sparking, connected at one of their ends to the main windings at points between the coil sections, and at the other end, to the commutator segments.

Commutator Segments. The insulated bars of a commutator.

Compensated Alternator. A separately excited alternator, which automatically compensates for the drop in voltage in its armature, or in its armature or the line, by sending around its field a rectified portion of the main current, or of the current derived from a series transformer in the main circuit.

Compensated Galvanometer. A differential galvanometer for indicating pressure at a distant point of a continuous-current circuit, having one coil in shunt and the other in series with said circuit.

Compensated Resistance-coil. A resistance-coil so arranged as to be compensated for the effect of temperature upon its resistance.

Compensated Voltmeter. A central-station voltmeter connected to the bus-bars in such a manner that its indications are automatically corrected for the drop of pressure in some particular feeder or group of feeders, so that its readings correspond to the pressure supplied to the mains.

Compensated Wattmeter. A wattmeter so wound as to be compensated for the effect of reactance in its shunt circuit.

Compensating Line. An artificial line employed in duplex telegraphy.

Compensating Pole. A small bar electro-magnet, or electro-magnetic coil, placed perpendicularly between the pole-pieces of a dynamo to compensate for the cross magnetization of the armature currents.

Compensator. An auto-transformer.

Compensator Potential Regulator. Sometimes called *Contact Regulators.* An apparatus in which a number of turns of one of the coils are adjustable.

Complete Wave. Two successive alternations, of a double alternation of a periodically-alternating quantity. A cycle.

Complex Quantities. Any quantity made up of two parts, one of which is measured along an axis of reference, and the other in a direction at right angles to such axis, these axes being sometimes described as the real and imaginary axes respectively.

Components of Impedance. The energy component or effective resistance and the wattless component or effective reactance.

Composite Excitation. Any excitation of the field magnets of a dynamo in which more than a single winding is employed, such as a shunt and a series winding.

Composite Field. The field of a compositely-excited dynamo.

Composite Wire. A wire provided with a steel core and an external copper sheath, possessing sufficient tensile strength to enable it to be used in long spans without excessive sagging. A bimetallic wire.

Compound. An asphaltic composition employed in the sheathing of submarine cables. A term often applied to insulating materials.

Compound Alternator. A compound-wound alternator.

Compound Magnet. A number of single magnets placed parallel, side by side, and with their similar poles adjacent.

Compound Winding. A method of winding dynamos or motors in which both shunt and series coils are placed on the field magnets.

Concentric Cable. A cable provided with both a leading and return conductor insulated from each other, and forming respectively the central core or conductor, and the enclosing tubular conductor. A cable having concentric conductors. (See Index.)

Concentric Conductors. Cylindrical coaxial conductors insulated from each other.

Concentric Mains. Mains employing concentric cables.

Condensance. Capacity reactance.

Condenser. A device for increasing the capacity of an insulated conductor by bringing it near another earth-connected conductor but separated therefrom by any medium that will permit electrostatic induction to take place through its mass. Any variety of electrostatic accumulator.

Condenser Capacity. The capacity of a condenser.

Condenser Circuit. Any circuit in which a condenser is inserted.

Condenser Pressure. The difference of potential at the terminals of a condenser.

Electrical Dictionary

Conduct. To pass electricity through conducting substances. To carry, or to possess the power of carrying an electric current.

Conductance. A word sometimes used in place of conducting power. The reciprocal of resistance. In a continuous-current circuit the ratio of the current strength to the E.M.F. In an alternating-current circuit the quantity whose square added to the square of the susceptance is equal to the square of the admittance.

Conductance, Electric. Conducting power for electricity.

Conduction, Electric. The so-called flow or passage of electricity through a metallic or other similar substance. The ability of a substance to determine the direction in which electric energy shall be transmitted through the ether surrounding it. The ability of a substance to determine the direction in which a current of electricity shall pass from one point to another.

Conduction, Electrolytic. A term sometimes employed to indicate the passage of electricity through an electrolyte.

Conductive. Possessing the power of conducting.

Conductivity, Electric. The reciprocal of electric resistivity. The conductance of a substance referred to unit dimensions.

Conductivity Resistance. The resistance offered by a substance to electric conduction or to the passage of electricity through its mass.

Conductor. Any substance which will permit the so-called passage of an electric current. A substance which possesses the ability of determining the direction in which electric energy shall pass through the ether in the dielectric surrounding it.

Conduit, Electric. An underground space, either single or provided with a number of separate spaces called ducts, employed for the reception of electric wires or cables.

Conduit Trolley-system. A single or double-trolley-system in which the trolley wire or wires are placed in an underground slotted conduit, the trolley wheel being replaced by a plow or sled pushed or drawn through the slot.

Connecting Jack. A jack for introducing a loop into a telephone circuit.

Connecting Sleeve. A metallic sleeve employed as a connector for readily joining the ends of two or more wires.

Connection in Cascade. A term sometimes employed for connection in series.

Connection, Multiple. Such a connection of a number of separate electric sources, or electro-receptive devices, or circuits, that all the positive terminals are connected to one main or positive conductor, and all the negative terminals are conducted to one main or negative conductor.

Connection, Series. The connection of a number of separate electric sources, or electro-receptive devices, or circuits, so that the current passes successively from the first to the last in the circuit.

Consequent Pole. A magnet pole formed by two free north or two free south poles placed together. A magnet pole developed at some point of a magnet other than its extremities.

Consonance. A phase agreement between two simple-periodic waves or vibrations. The reinforcement of sound waves, or their increase in intensity, by means of vibrating bodies that are not in resonance with, or are tuned to vibrate in unison with, the sounding body. Forced unison.

Consonance, Electric. In an alternating-current circuit the co-phasing of the impressed E.M.F. with the primary current, due to the influence of capacity in an inductively associated secondary circuit. A circuit in which the capacity and the inductance are equal and opposite in effect.

Constant. Of an electrical instrument is that quantity which used as a factor with indications of instruments gives results in the desired unit. Of a watt-hour meter is 3600 × watt-hours passing through the circuit during one revolution of the meter disc.

Constant Current.—A direct current or one that always flows in the same direction. A current whose strength is unvarying.

Constant-current Transformer. A transformer which is intended to raise or reduce a current strength in a given constant ratio. A transformer designed to maintain a constant strength of current in its secondary circuit, despite changes of load.

Constant-potential Circuit. A circuit whose potential is maintained approximately constant. A multiple-arc or parallel-connected circuit.

Constant-potential Dynamo. A dynamo that furnishes an approximately constant difference of potential or electromotive force despite changes in its resistance or load. A shunt or compound-wound dynamo.

Contact Breaker. A device for breaking or opening an electric circuit.

Contact Regulator. See Compensator Potential Regulator.

Contact Resistance. Resistance produced at the contact of two or more surfaces.

Contact Rings of Alternator. The collector rings of an alternator.

Contact Screw. A screw the end of which is provided with a platinum or other contact, employed to close the circuit of any electric device in whose circuit it is placed.

Contacts. Conducting pieces or plates introduced into electric circuits at points where it is desired to open and close the circuit. A variety of fault occasioned in any circuit by the accidental contact of any part of the circuit with a conducting body. A metallic cross or faulty connection between two telegraphic or telephonic circuits.

Continuous-alternating Transformer. A secondary generator for transforming continuous into alternating currents. A dynamometer, motor-dynamo, or rotary transformer.

Continuous Current. An electric current which flows in one and the same direction. A steady or non-pulsating direct current.

Continuous-current Generator. Any generator capable of furnishing continuous currents.

Continuous-current Transformer. A dynamo or motor-dynamo. A transformer from one continuous pressure and current to another.

Controller. The magnet employed in a system of automatic constant-current regulation, whose coils are traversed by the main current, employed automatically to throw a regulator magnet into or out of the main circuit on changes of the current passing. Any electric mechanism for controlling a circuit or system. An electric switching mechanism for controlling the speed of a motor or motors. A street-railway car controller.

Controller Switch. The switch operating the switch cylinder of a street-car controller. Any switch employed in connection with a street-car controller.

Controlling Magnet. Any magnet which controls some particular action, as, for example, the attraction of a needle in a galvanometer. A name sometimes given to the controller in an automatic system of current regulation.

Convection Currents. Currents produced by the bodily carrying forward of static charges in convection streams.

Convective Discharge. The discharge which occurs from the points of a highly charged conductor, through the electrostatic repulsion of similarly charged air particles, which thus carry off minute charges.

Converter. A dynamo-electric machine having one armature and one field for converting alternating current to direct current, or direct current to alternating current. The term to be preceded by the words "alternating current-direct current" (A.C.-D.C.) or "direct current" (D.C.).

Converted Currents. Electric currents whose strengths have been increased or decreased by means of a transformer.

Co-periodic. Possessing the same periodicity.

Co-phase. Coincidence in phase of co-periodic motions. Such a phase relation between two periodic but non-co-periodic quantities as tends to increase the amplitude of the motion.

Copper, Cu. At. wt. 63.2, Sp. gr. 8.81 to 8.95. Fuses at about 1930° F. Distinguished from all other metals by its reddish color. Very ductile and malleable and its tenacity is next to iron. Tensile strength 20,000 to 30,000 lbs. per square inch. Heat conductivity 73.6% of that of silver and superior to that of other metals. Electric conductivity equal to that of gold and silver. Expansion by heat from 32° to 212° F. 0.0051 of its volume. (Kent) (See Index.)

Copper Loss. The total loss of energy produced by the passage of a current through the copper wire of a dynamo, motor, or conducting system generally.

Copper Tape. Rectangular straps or bars of copper employed for armature windings.

Copper Voltameter. A voltameter whose indications are dependent on the electrolysis of a solution of a copper salt.

Cord, Electric. A flexible, insulated electric conductor, generally containing two parallel wires.

Core, Lamination of. Structural subdivisions of the cores of magnets, armatures, and pole-pieces of dynamo-electric machines, electric motors, or similar apparatus, in order to prevent heating and subsequent loss of energy from the production of local, eddy or Foucault currents.

These laminations are obtained by forming the cores of sheets, rods, plates, or wires of iron insulated from one another. (See Silico-Magnetic Core Steel.)

Core Losses. The hysteresis and the Foucault or eddy-current losses of the core of a dynamo, motor or transformer.

Core of Cable. The insulated wires employed for the transmission of the current through a conducting cable. The electric conductor and insulator as distinguished from the mechanical serving and sheathing of a cable.

Corona. The name given to a brush discharge surrounding aerial conductors which carry high potential current. The discharge is red violet in color, gives a hissing sound and is probably intermittent in character.

Corona, Electrostatic. A luminous effect produced on the surface of a thin sheet of mica, or other similar insulating material, when placed between two electrodes between which discharges of comparatively high difference of potential are passing.

Corrective Motor. A synchronous motor running either idle or under load, whose field charge may be varied so as to modify the power-factor of the circuit to which it is connected or through such modification to also influence the voltage of the circuit (this term is proposed instead of the term "rotating condenser").

Corrosion, Electrolytic. A term frequently employed for the corrosion of water or gas pipes or other masses of metal buried in the earth by electrolytic action.

Cosine. One of the trigonometrical functions. The ratio of the base to the hypothenuse of a right-angled triangle in which the hypothenuse is the radius vector, and the angle between the base and hypothenuse the angle whose cosine is considered.

Coulomb. The practical unit of electric quantity. Such a quantity of electricity as would pass in one second through a circuit conveying one ampere.

The quantity of electricity contained in a condenser of one farad capacity, when subjected to the E.M.F. of one volt. (See International Coulomb.)

Coulomb Meter. A meter for measuring in coulombs, the quantity of electricity which passes through any circuit.

Coulomb-volt. A word sometimes employed for the volt-coulomb or joule.

Counter-electromotive Force. An opposed or reverse electromotive force which tends to set up a current in the opposite direction to that actually produced by a source. In an electric motor, an electromotive force produced by the rotation of the armature and opposed to that produced by the driving current.

Counter-electromotive Force of Induction. The counter electromotive force of self or mutual induction.

Couple. In mechanics, two equal and parallel, but oppositely directed forces, not acting in the same line, and tending to produce rotation. The two elements in a voltaic cell or thermo-electric cell.

Couple, Thermo-electric. Two dissimilar metals which, when connected at their ends only, so as to form a completed electric circuit, will produce a difference of potential, and hence an electric current, when one of the ends is heated more than the other.

Couple, Voltaic. Two materials, usually two dissimilar metals, capable of acting as an electric source when dipped in an electrolyte, or capable of producing a difference of electric potential by mere contact.

Cradle Dynamometer. A dynamometer in which the dynamo to be tested is supported in a cradle, and the mechanical energy it receives or transmits is measured by the torque developed by the cradle about its axis.

Critical Current. The current strength at which a certain critical result is reached.

Critical-speed of Compound-wound Dynamo. The speed at which both the series and shunt coils of a dynamo give the same difference of potential when the full load is on the machine, as the shunt coil would have if used alone on open-circuit. The speed at which a dynamo commences to build up its excitation.

Crookes' Effect. The effect produced in high-vacuum tubes due to the characteristic motions possessed by heated or electrified molecules when in the ultra-gaseous or radiant state.

Crookes' Tubes. Glass tubes containing high vacua, provided with platinum leading-in wires terminating in suitably shaped metallic surfaces, employed in demonstrating the peculiarities of the radiant or ultragaseous condition of matter. A name frequently given to X-ray tubes.

Cross. See Cross, Electric.

Cross Arm. A horizontal beam attached to a pole for the support of the insulators of telegraph, electric light, or other electric wires. A telegraphic arm.

Cross Bonding. In an electric railway the bonding between the ground feeder and the track for the purpose of ensuring a good conducting return circuit.

Cross-connection of Armature Windings. Armature windings in which the wires are interconnected at the corresponding segments of the commutator.

Cross Current. Current passing between the armatures of alternating current generators, or motors, operated in parallel, and due to differences in the phase or magnitude of the E.M.F.'s in the machines.

Cross, Electric. A connection, generally metallic, accidentally established between two conducting lines. A defect in a telegraph, telephone, or other circuit, caused by two wires coming into contact by crossing each other.

Electrical Dictionary

Cross Induction. An induction produced by the armature current whose magnetization is at right-angles to that produced by the field. Cross magnetization.

Cross Magnetization. A magnetization set up by the currents circulating in the armature turns, which is at right-angles to the magnetization set up by the field flux.

Cross-talk. Cross-fire conversation over one telephone circuit which is heard in neighboring telephone circuit. Interference between neighboring telephone circuits.

Crow-foot Zinc. A crow-foot-shaped zinc employed in the gravity voltaic cell.

Crucible Steel. (See Index.)

Current Commuter. Any device that causes alternating currents to flow in one and the same direction. A commutator.

Current Density. The current strength which passes in any part of a circuit, divided by the area of cross-section of that part of the circuit. The ratio of the current strength through any surface of section of active conductor to the area of that surface, assumed perpendicular to the current.

Current Distribution. The spreading or ramification of electric currents through a conducting mass or network.

Currents, Eddy. See Eddy Currents.

Current, Electric. The quantity of electricity per-second which passes through any conductor or circuit, when the flow is uniform. The rate at which a quantity of electricity flows or passes through a circuit. The ratio, expressed in terms of electric quantity per-second, existing between the electromotive force causing a current and the resistance which opposes it.

The unit of current, or the ampere, is equal to one coulomb per second. (See Ampere, and Coulomb.)

The word current must not be confounded with the mere act of flowing; electric current signifies rate of flow, and always supposes an electromotive force to produce the current, and a resistance to oppose it.

The electric current is assumed to flow out from the positive terminal of a source, through the circuit and back into the source at the negative terminal. It is assumed to flow into the positive terminal of an electro receptive device such as a lamp, motor, or storage battery, and out of its negative terminal; or, in other words, the positive pole of the source is always connected to the positive terminal of the electro-receptive device.

The current that flows or passes in any circuit is, in the case of a constant current, equal to the electromotive force, or difference of potential, divided by the resistance, as:

$$C = \frac{E}{R}$$

(See Law of Ohm.)

The flow of an electric current may vary in any manner whatsoever.

A current which continues flowing in the same direction no matter how its strength may vary, is called a continuous current, or sometimes a direct current. If the strength of such a current is constant, it is called an unvarying current; if its strength is not constant, it is a varying continuous current. A regular varying continuous current is called a pulsatory current. A current which alternately flows in opposite directions, no matter how its strength may vary, is called an alternating current. This may be periodic or non-periodic.

Current, Electric, Method of Propagation of, Through a Circuit. When an electric current is propagated through a wire or other conductor, it is not sent or pushed through the conductor, like a fluid through a pipe or other conductor, but is, so to speak, handed on from particle to particle.

The following taken from the "Electrical World," March 3, 1910, represents the latest hypothesis concerning these phenomena:

"In the normal unelectrified state all the copper molecules are substantially neutral. When an electric potential difference, or voltage, is applied to the ends of the copper wire, the negative electrons at the positive pole jump out of the adjacent molecules, leaving them positively electrified. These, in their turn, attract more negative electrons out of the next layer of neutrals beyond and so on, back to the negative pole, until there is a complete bucket brigade, formed by the molecules, the buckets being the negative electrons and the firemen being the nearly stationary molecules, which pass negative electricity all along the line."

Current, Faradic. In electro-therapeutics, the current produced by an induction coil, or by a magneto-electric machine. A rapidly alternating current, as distinguished from a uniform voltaic current.

Current, Foucault. A name sometimes applied to eddy currents, especially in armature cores.

Current, Periodic. A simple periodic current.

Current, Polyphase. Currents differing in phase from one another and, therefore, requiring separate circuits for use.

Current Retarder. A term sometimes employed for rheostat.

Current Reverser. A switch or other apparatus designed to reverse the direction of a current. A current changer.

Current, Rotating. A term applied to the current which results by combining a number of alternating currents whose phases are displaced with respect to one another.

Current Rush. The impulsive rush of current that occurs when a transformer is first switched on, or connected with, an alternating-current circuit.

Current, Simple Periodic. Currents, the flow of which is variable, both in strength and duration, and in which the flow of electricity, passing any section of the conductor, may be represented by a simple periodic curve.

Current Strength. In a direct-current circuit the quotient of the total electromotive force divided by the total resistance. The time-rate-of-flow in a circuit expressed in amperes, or coulombs per second. In an alternating current the quotient of the total electromotive force divided by the impedance. (See Alternating Currents.)

Current Transformation. The act of changing the strength of a current by changes effected in its electromotive force. The act of changing a direct into an alternating current, or the reverse, or a uniphase-alternating current into a multiphase-alternating current.

Current Transformer. A device for changing in one circuit the strength of current which flows in another.

Current Turns. The product of the number of turns in a coil by the current flowing through them. A word sometimes used for ampere-turns.

Current, Undulatory. Currents the strength and direction of whose flow gradually change.

Cut-out. A device for removing an electro-receptive device or loop from the circuit of an electric source. A safety fuse.

Cut-out Block. A block containing a fuse wire or safety catch.

Cut-out Cabinet. Any enclosed space provided in a building for the reception of cut-outs or fuses.

Cut-out Switch. A short-circuiting switch by means of which an arc-light is cut out from its feeding circuit.

Cycle. A succession of events which periodically recur, reckoning from any stage of the disturbance to the moment at which that stage next occurs. A complete recurrence of any periodic change.

Electrical Dictionary

Cycle of Alternations. The cycle of a periodically-alternating electromotive force, current or flux.

D.

d. A symbol for diameter.

D.C. A contraction for direct current.

D.P. Cut=out. A contraction for double-pole cut-out.

D.P. Switch. A contraction for double-pole switch.

Damped Magnetic Needle. A magnetic needle so placed as to come quickly to rest after it has been set in motion.

Damper. A metallic cylinder so arranged as to partially or completely surround the iron core of an induction coil for the purpose of varying the intensity of the currents produced in the secondary. A dash-pot, or similar apparatus, provided for preventing the too sudden movements of a lever or other part of a moving device. Any device employed for damping a magnetic needle.

Damping Magnet. Any magnet employed for the purpose of checking the motions of a moving body or magnet.

Damping Suspension. A suspension which is rendered dead-beat, or aperiodic, by the application of any retarding force or damping mechanism.

Daniell's Voltaic Cell. A zinc-copper couple whose elements are immersed respectively in electrolytes of dilute sulphuric acid and a saturated solution of copper sulphate.

d'Arsonval Galvanometer. The class of galvanometers in which the needle or mirror is attached to and actuated by a small coil which is suspended by means of a fine wire between the poles of a permanent magnet. The axis of the coil is normally at right angles with the lines of the field. Current is lead into the coil by means of the small suspension wire and leaves the coil by a flexible wire usually in the form of a helical spring attached underneath the coil.

Dead=beat Galvanometer. An aperiodic galvanometer, or one whose needle comes quickly to rest instead of repeatedly swinging to-and-fro. A heavily damped galvanometer.

Dead=ended Conductor or Wire. A conductor or wire whose end is deliberately left open or insulated as, for example, by being wound around an insulator.

Dead Ground or Grounding. Such a grounding as will ensure a ground of negligible resistance.

Dead Man. A support for raising a pole and supporting it in place while securing it in the ground.

Deci=ampere. One-tenth of an ampere.

Deflecting Magnet. The permanent magnet of a magnetometer, employed for deflecting a small magnetic needle suspended at a definite distance, in order to compare its influence with that of the earth's horizontal magnetic force. The compensating magnet of a galvanometer.

Deka=ampere. Ten amperes.

Delta Connection. The connection of circuits employed in a delta triphase-system.

Delta Current. The current between adjacent wires or terminals of a triphase-system. The ring current.

Delta Triphase=system. A triphase-system in which the terminal connections resemble the Greek letter delta, or triangle.

Demagnetizing Current. The current which serves to remove the magnetization of some magnetic device.

Demand. Demand is a load specified, contracted for or used, expressed in terms of power as K.-W. or P.

Demand Factor. Unless otherwise specified, demand factor shall be the maximum connected kilowatts of capacity divided into the actual kilowatts of demand, and expressed in terms of per cent.

Demand Rate. The price, or part of the price, of power charged for the demand as designated for the price paid for the kilowatt-hour consumption.

Density. Mass of unit volume, compactness.

Density, Electric. The quantity of free electricity on any unit of area of surface of a charged body.

Density of Current. The quantity of current that passes per-unit-of-area of cross-section in any part of a circuit.

Density of Field. The quantity of magnetic flux that passes through any field per-unit-of-area of cross-section.

Depolarize. To deprive of polarization.

Detector Galvanometer. Any rough form of galvanometer or galvanoscope employed for detecting the presence of electric currents.

Detector, Ground. See Ground Detector.

Developed Winding. A winding of a dynamo-electric machine developed or expanded upon a drawing of plane.

Dial Telegraphy. A system of telegraphy in which the messages are received by the movements of a needle over a dial plate.

Diamagnetic. The property possessed by substances like bismuth, phosphorus, antimony, zinc and others, of being apparently repelled when placed between the poles of powerful magnets.

Diameter of Commutation. The diameter of the commutator cylinder of a dynamo at which the brushes are applied. That diameter on the commutator cylinder of an open-circuit armature, which joins the points of contact of the collecting brushes.

Dielectric. Any substance which permits electrostatic induction to take place through its mass.

The substance which separates the opposite coatings of a condenser is called the dielectric. All dielectrics are non-conductors.

All non-conductors or insulators are dielectrics, but their dielectric power is not exactly proportional to their non-conducting power.

Substances differ greatly in the degree or extent to which they permit induction to take place through or across them. Thus, a certain amount of inductive action takes place between the insulated metal plates of a condenser across the layer or air between them.

A dielectric may be regarded as pervious to rapidly reversed periodic currents, but opaque to continuous currents. There is, however, some conduction of continuous currents.

Dielectric Capacity. A term employed in the same sense as specific inductive capacity.

Dielectric Hysteresis. A variety of molecular friction, analogous to magnetic hysteresis produced in a dielectric under charges of electrostatic stress. That property of a dielectric by virtue of which energy is consumed in reversals of electrification. (See page 20.)

Dielectric Resistance. The resistance which a dielectric offers to mechanical strains produced by electrification. The resistance of a dielectric to displacement currents.

Dielectric Strain. The strained condition of the glass or other dielectric of a condenser produced by the charging of the condenser. The deformation of a dielectric under the influence of an electro-magnetic stress.

Difference of Electric Potential. That quantitative property in space whereby work is done when an electric charge is moved therein. The electric work done on a unit charge in an excursion between two points.

Differential Coils. Coils that are differentially wound, or that act differentially.

Differential Galvanometer. A galvanometer containing two coils, so wound as to tend to deflect its needle in opposite directions.

Differential Rate. A rate consisting of two opposed factors; one tending to give a high rate and the other tending to give a low rate.

Electrical Dictionary

Differential Relay. A telegraphic relay containing two differentially wound coils of wire on its magnet core.

Differential Speed. In an induction machine, the angular velocity of the field relatively to the rotor.

Differential Voltmeter. A voltmeter consisting of two separate decomposition cells, one placed in a circuit of known resistance, and the other in a circuit whose resistance is to be determined.

Differential Winding. Such a double winding of magnet coils that the two poles produced thereby are opposed to each other.

Dimmer. A choking coil employed in an alternating-current system of distribution for regulating the current strength passing through incandescent lamps.

Dip. The inclination of a magnetic needle.

Diphase=alternating Currents. Two separate alternating electric currents whose phase difference is a quarter of a cycle. Two-phase currents. Quarter-phase currents.

Diphase Alternator. An alternator that produces diphase E.M.F.'s.

Diphase Circuit. A circuit, consisting either of three or four separate wires, employed for the transmission of diphase currents.

Diphase Generator. A generator capable of producing diphase E.M.F.'s. A diphase alternator.

Diphase=triphase Transformer. A transformer for converting diphase into triphase currents.

Dipolar. Possessing two poles. Bipolar.

Dipping. An electro-metallurgical process whereby a thin coating or deposit of metal is obtained on the surface of another metal by dipping it in a solution of a readily decomposable metallic salt. Cleansing surfaces for electro-plating by immersing them in various acid liquors.

Dipping Magnetic=needle. A magnetic needle suspended so as to be free to move in a vertical plane only, and employed to determine the angle of dip or magnetic inclination. An inclination compass.

Direct=current. A current whose direction is constant, as distinguished from an alternating current. A unidirectional current.

Direct-current Converter. Converts from a direct current to a direct current of different voltage.

Direct=current Generator. Any dynamo-electric machine capable of furnishing direct currents, that may or may not be continuous.

Direct=current Transformer. A transformer intended to vary the strength of continuous currents. A direct-current secondary-generator.

Direct Excitation. The excitation of a muscle, resulting from the placing of an electrode directly on the muscle itself. The excitation of a dynamo-electric machine by a separate source of direct currents, as distinguished from its excitation by commuted currents taken from its own armature.

Disc Armature. The armature of a dynamo-electric machine whose windings consist of flat coils supported on the surface of a disc. An armature having the form of a disc.

Discharge. The equalization of the difference of potential between the terminals of a condenser or source, on their connection by a conductor. The removal of a charge from a conductor by connecting the conductor to the earth or to another conductor. The removal of a charge from an insulated conductor by means of a stream of electrified air particles.

Discharge Key. A key employed to pass the discharge from a condenser or cable through a galvanometer.

Disconnector. A key or other device for opening or breaking an electric circuit or for removing an electro-receptive device therefrom.

Discriminating Rate. A rate which does not give the same price to two or more customers, when all other conditions are equal.

Dispersion Factor. The factor applied to light intensity after dispersion, which gives the intensity if the dispersion agent were removed.

Displacement Current. The rate-of-change of electric displacement. An electric current produced in a dielectric by electric displacement, as opposed to a conduction current.

Disruptive Discharge. A sudden and more or less complete discharge that takes place across an intervening non-conductor or dielectric.

Disruptive Strength of Dielectric. The strain a dielectric is capable of bearing without suffering disruption, or without permitting a disruptive discharge to pass through it.

Dissipation of Energy. The expenditure or loss of available energy.

Distributed Capacity. The capacity of a circuit considered as distributed over its entire length, so that the circuit may be considered as shunted by an infinite number of infinitely small condensers, placed infinitely near together, as distinguished from localized capacity, in which the capacity is distributed in discrete aggregations.

Distributed Inductance. Inductance distributed through the entire length of a circuit or portion thereof, as distinguished from inductance interposed in a circuit in bulk at some one or more points.

Distributing Mains. The mains employed in a feeder system of parallel distribution.

Distributing Station. A station from which electricity is distributed. A central station.

Distributing Center. In an electrical distribution system a center or sub-center of distribution. A ramifying point.

Diurnal Currents. Earth currents through telegraph circuits of normal strength and executing diurnal cycles.

Diversity Factor. A diversity factor is used to express the relation between the simultaneous demand of all individual customers and the sum of the maximum demand made by these customers; the sum of the maximum demand of the customers, no matter at what time they occurred, divided into the simultaneous greatest maximum demand when expressed in per cent will give the diversity factor.

Double Alternation. A complete cycle or double vibration. A complete to-and-fro movement.

Double=break Switch. A double-pole switch. A switch which breaks a circuit in two places as distinguished from a switch which breaks a circuit at a single point only.

Double-current Generator. One which produces both direct and alternating currents.

Double=current Working. A method of telegraphic working or transmission by means of double currents.

Double=filament Lamp. An incandescent lamp, frequently employed for the side-light of a ship, and provided with two carbon filaments so arranged that should one break, the other will continue burning. A twin-filament lamp. An incandescent lamp having two filaments connected in series, and therefore, requiring twice the electric pressure of an ordinary lamp.

Double=loop. In telegraphy, any pair of associated loops. A pair of loops connecting a pair of branch offices with a central office.

Double=pole Switch. A switch which simultaneously breaks the circuit of both positive and negative leads.

Double=throw Switch. A switch capable of being thrown into either of two contacts or pairs of contacts. A switch which has three positions. A throw-over switch.

Double=transmission. The simultaneous sending of two messages over a single wire in opposite directions. Duplex or contraplex telegraphy.

Double=trolley. Two separate trolleys placed on the same car, and moving over two separate trolley wires which form a metallic circuit, in any double-overhead system.

Draw Vise. A device employed in stringing overhead wires. A portable vise for holding and drawing up an overhead wire.

Electrical Dictionary

Drop. A word frequently used for drop of potential, pressure, or electromotive force. The fall of potential which takes place in an active conductor by reason of its resistance.

Drop of Magnetic Potential. A fall of magnetic potential.

Drop of Potential. The fall of potential, equal in any part of a circuit to the product of the current strength and the resistance of that part of the circuit.

Drop of Voltage. The drop or difference of potential of any part of a circuit.

Drum Armature. A dynamo armature whose coils are wound longitudinally over the surface of a cylinder or drum.

Dry Battery. A number of separate dry voltaic cells, connected so as to act as a single source. A dry pile.

Dry Cell. A dry voltaic cell.

Dry Voltaic Cell. A misnomer for a voltaic cell in which the fluid electrolyte is held in suspension by sawdust, gelatine, or other suitable material. A sealed voltaic cell, which can, therefore, be inverted without danger of spilling liquid.

Duct. A space left in an underground conduit for a sparate wire or cable.

Duplex Cable. A cable containing two separate conductors placed parallel to each other.

Duplex Circuit. A circuit arranged for duplex transmission. A metallic circuit.

Duplex Telegraphy. A system of telegraphy whereby two messages can be simultaneously transmitted in opposite directions over a single wire.

Duplex Transmission. The sending of two telegraphic or telephonic messages simultaneously in opposite directions over the same wire.

Duplex Wire. An insulated conductor containing two separate parallel wires.

Dust Telephone-transmitter. A form of microphone transmitter in which finely granulated carbon or carbon dust is contained within a suitably shaped box, connected with the terminals of the transmitter. A granular telephone transmitter.

Dynamic Electricity. A term sometimes employed for current electricity, in contradistinction to static electricity.

Dynamo. A dynamo-electric machine or generator.

Dynamo Battery. The combination of several separate dynamos to act as a single electric source.

Dynamo-electric Machine. A machine for the conversion of mechanical energy into electric energy, by means of electro-dynamic induction. A dynamo.

Dynamo Regulator. A name given to a form of rheostat employed in the regulation of a dynamo.

Dynamo Terminals. The main terminals of a dynamo.

Dynamometer. A general name given to a variety of apparatus for measuring power.

Dynamotor. A particular type of rotary transformer. A motor-generator, in which a generator and a motor armature are rotated through a common magnetic field. A transforming device.

Dyne. The C.G.S. unit of force. The force which in one second can impart a velocity of one centimetre-per-second to a mass of one gramme.

E.

E. or e. A symbol for electromotive force.

E.H.P. A contraction for electrical horse-power.

E.M.F. A contraction for electromotive force.

E.M.F. of Self-induction. The E.M.F. generated in a loop of wire during the filling or emptying of that loop by magnetic flux from its own current.

Ear. A metal piece supported by an insulator to which the trolley wire is fastened. A trolley ear.

Earth. A fault in a telegraphic or other line caused by the accidental contact of the line with the ground or earth, or with some other ground-connected conductor. That part of the earth or ground which forms a part of an electric circuit.

Earth Circuit. A circuit in which the ground or earth forms part of the conducting path.

Earth Currents. Electric currents flowing through the earth, caused by the difference of potential of its different parts.

Earth Plates. Plates of metal, buried in the earth or in water, connected to the terminals of earth wires.

Earth Return. That portion of a grounded circuit in which the earth forms its conducting path.

Earth's Field. The magnetic field produced in any place by the earth's flux.

Earth's Flux. The magnetic flux produced by the earth by virtue of its magnetized condition.

Easement. A permit obtained from the owner of a property for the erection of poles or attachments for telephone, telegraph, or other aerial lines.

Ebonite. A hard, tough, black substance, composed of India rubber and sulphur, possessing both high powers of insulation and high specific inductive capacity. Vulcanite.

Economic Coefficient. The ratio between the net electric power, or the output of a dynamo, and the gross electric power, or power actually converted in the dynamo.

Economizer. An apparatus placed between a boiler furnace and a smoke stack to utilize a portion of the heat of the flue gases that would otherwise be lost. It is made up of a series of tubes over which the gases have to pass and through which the boiler feed water flows. A portion of the waste heat of the flue gases thus passes into the water and raises its temperature.

Eddy Currents. Useless currents produced in the pole-pieces, armature, and field-magnet cores of dynamos or motors, or in metallic masses generally, either by their motion through magnetic flux, or by variations in the strength of electric currents flowing near them.

Effective Ampere-turns. The resultant magnetizing force in a magnetic circuit. The square root of the mean square of the ampere-turns in a periodically-varying magnetizing force.

Effective Current-strength. The strength of an alternating or sinusoidal-electric current, determined by its heating effect; or, in other words, the thermally effective current strength. That value of the current strength of a sinusoidal or alternating current which is equal to the square root of the mean square of the instantaneous values of the current during one or more cycles. The square root of the time average of the square of the current.

Effective Demand. The demand taken at the time of the system's greatest maximum.

Effective Electromotive Force. The difference between the direct and the counter-electromotive force. The square root of the time average of the square of the E.M.F. The virtual E.M.F.

Effective Load-factor. The meaning suggested is the main load of a part of a system determined by the load at the time of the system's maximum. This value would be infinity if the service were off at the time of the system's maximum as in the case of non-peak service. The term "effective demand" is suggested as a substitute.

Effective Reactance. In an alternating-current circuit, the ratio of the wattless component of an electromotive force to the total current. Apparent reactance.

Effective Resistance. In an alternating-current circuit, the ratio between the energy component of an electromotive force and the total current.

Electrical Dictionary

Efficiency. The efficiency of an apparatus is the ratio of its output to its input. The output and input may be in terms of watt-hours, watts, volt-amperes, amperes, or any other quantity of interest, thus respectively defining energy efficiency, power efficiency, apparent-power efficiency, current efficiency, etc. Unless otherwise specified, however, the term efficiency is ordinarily assumed to refer to power efficiency.

When the input and output are expressed in terms of the same unit, the efficiency is a numerical ratio, otherwise it is a physical dimensional quantity.

Elastic Limit. This may be defined as that point at which the deformation ceases to be proportional to the stresses, or, the point at which the rate of stretch or other deformations begin to increase. It is also defined as the point at which the first permanent set becomes visible.

Elasticity, Electric. The quotient arising from dividing the electric strain by the electric stress.

Electric. Of or pertaining to electricity.

Electric Current. See Current, Electric.

Electrical. An orthography for electric.

Electrically Retarded. Decreased speed of telegraphic signalling by means of electrostatic induction.

Electricity. The name given to the unknown cause of electric phenomena. (See Current, Electric.)

Electrification. The production of an electric charge.

Electro-chemical. Of or pertaining to electrochemistry.

Electro-chemical Series. A list of chemical elements so arranged that each will displace from its compounds any elements lower in the list than itself.

Electro-chemistry. That branch of electric science which treats of electric combinations and decompositions effected by the electric current. The science which treats of the relation between the laws of electricity and chemistry.

Electro-deposition. The deposit, usually of a metallic substance, by means of electrolysis. Electrolytic deposition.

Electro-dynamic Force. A mechanical force exerted on the substance of a wire or conductor due to the dissymmetrical distribution of magnetic flux in its neighborhood.

Electro-dynamic Machinery. Any apparatus designed for the production, transference, utilization, or measurement of energy by the medium of electricity.

Electro-dynamic Potential. An electric potential produced by electro-dynamic induction.

Electro-dynamics. That branch of electric science which treats of the action of electric currents on one another, on themselves, or on magnets.

Electro-magnet. A magnet produced by the passage of an electric current through a circuit of insulated wire. A magnetizing coil surrounding a soft iron core, that is capable of being magnetized and demagnetized instantly on the closing and opening of the circuit.

Electro-magnetic Field. The field produced either by an electro-magnet or by an electric current.

Electro-magnetic Flux. Magnetic flux produced by means of an electro-magnet or by an electric current.

Electro-magnetic Induction. A variety of electro-dynamic induction in which electric currents are produced by the motion either of electro-magnets, or electro-magnetic solenoids.

Electro-magnetic Separator. A device for separating iron ore from the dross in finely-pulverized, low-grade iron ores. A device for magnetically removing particles of iron from brass filings or other non-magnetic material, and thus freeing such material from impurities.

Electro-magnetic Strain. The effect produced by an electro-magnetic stress.

Electro-magnetic Stress. The force or pressure in an electro-magnetic field which produces a strain or deformation in a piece of glass or other substances placed therein.

Electro-magnetic Telegraph. A general term embracing the apparatus employed in a system of electro-magnetic telegraphy.

Electro-magnetic Units. A system of C.G.S. units employed in electro-magnetic measurements. Units based on the attraction and repulsions capable of being exerted between two unit magnetic poles at unit distance apart, or between a unit magnetic pole and a unit electric current.

Electro-magnetic Voltmeter. A form of voltmeter in which the difference of potential is measured by the movements of a magnetic needle in the field of an electro-magnet.

Electro-magnetism. Magnetism produced by means of electric currents.

Electro-metallurgy. That branch of electric science which relates to the electric reduction or treatment of metals. Electro-metallurgical processes effected by the agency of electricity. Electro-plating or electro-typing.

Electro-negative. In such a state as regards electricity as to be repelled by bodies negatively electrified, and attracted by those positively electrified. The ions or radicals which appear at the anode or positive electrode of a decomposition cell.

Electro-negative Ions. The negative ions, or groups of atoms or radicals, which appear at the anode or positive terminal of a decomposition cell. The anions.

Electro-plating. The process of covering any conducting surface with a metal, by the aid of an electric current.

Electro-positive. In such a state, as regards an electric charge, as to be attracted by a body negatively electrified, and repelled by a body positively electrified. The ions or radicals which appear at the cathode or negative electrode of a decomposition cell.

Electro-positive Ions. The cathions or groups of atoms or radicals which appear at the cathode of a decomposition cell.

Electro-pyrometer. An apparatus for the determination of temperature by the measurement of the electric resistance of a platinum wire exposed to the temperature which is to be measured.

Electro-refining. Various processes for the electric refining of metals.

Electro-smelting. The separation or reduction of metallic substances from their ores, by means of the heat developed by electric currents.

Electro-technics. The science which treats of the technical applications of electricity and the general principles involved therein.

Electro-therapeutics. The application of electricity to the human body for the curing of disease or the improvement of health. Electro-therapy.

Electro-thermic. Of or pertaining to the generation of heat by means of electricity.

Electro-type. To produce a fac-simile by electrolytically depositing metals in a mould.

Electrode. Either of the terminals of an electric source. Either of the terminals of an electric source that are placed in a solution in which electrolysis is taking place. Either of the electro-therapeutic terminals of an electric source.

Electrograph. A curve produced by a recording electrometer. A word sometimes used for radiograph.

Electrolier. A chandelier for holding electric lamps, as distinguished from a chandelier for holding gas burners.

Electrolysis. Chemical decomposition effected by means of an electric current. The decomposition of the molecule of an electrolyte into its ions or radicals. Electrolytic decomposition.

Electrolysis of Salts. The electrolytic decomposition of a salt into its constituent ions or radicals.

Electrolyte. Any compound liquid which is separable into its constituent ions or radicals by the passage of electricity through it. The exciting liquid in a voltaic cell.

Electrolytic. Of or pertaining to electrolysis.

Electrolytic Bath. An electrolytic cell.

Electrolytic Cell. A cell or vessel containing an electrolyte in which electrolysis is carried on. A plating cell or vat.

Electrolytic Corrosion. The corrosion by electrolytic action of water-pipes, gas-pipes or other masses of metal, buried in moist earth.

Electrolytic Decomposition. The separation of a molecule into its constituent ions or radicals by the action of an electric current.

Electrolytic Heating. A method of electric heating consisting in plunging the metal to be heated beneath the surface of a conducting liquid, while held in a metal clamp that is connected to the negative pole of a continuous-current source, while the positive pole of such source is connected to the metal lining of the vessel containing the conducting liquid.

Electrolyze. To separate or decompose by means of electricity.

Electrometer. An apparatus for measuring differences of electric potential.

Electromotive Force. The force which starts or tends to start electricity in motion. The maximum or total generated difference of potential which exists in a circuit.

Electromotive Force of Induction. The electromotive force developed by any inductive action.

Electron. A word formerly used for amber. The electric atoms whose projection from the cathode of a high-vacuum tube is supposed to constitute the cathode rays or streamings. An alloy of gold and silver.

Electrophorus. A simple form of electrostatic induction apparatus.

Electroscope. An apparatus for showing the presence of an electric charge, or determining its character, whether positive or negative, but not for measuring its amount or value.

Electrostatic Capacity. The quantity of electricity which must be imparted to a given conductor as a charge, in order to raise its potential to unity, all neighboring conductors being at zero potential.

Electrostatic Corona. A luminous effect produced on the surface of a thin sheet of mica, or other insulating material, when placed between two electrodes, subjected to a comparatively high difference of potential.

Electrostatic Discharge. A term sometimes employed for a disruptive discharge.

Electrostatic Field. The region of electrostatic influence surrounding a charged body. A region traversed by electrostatic flux.

Electrostatic Force. The force which produces the attractions or repulsions of charged bodies.

Electrostatic Induction. The induction of an electric charge produced in a conductor brought into an electrostatic field.

Electrostatic Lines of Force. Lines of force produced in the neighborhood of a charged body, by the presence of the charge. Lines extending in the direction in which the force of electrostatic attraction or repulsion acts.

Electrostatic Potential. The power of doing electric work possessed by a unit quantity of positive electricity residing on the surface of an insulated body. That property in space by virtue of which work is done when an electric charge is moved therein.

Electrostatic Units. Units based on the attractions or repulsions of two unit charges of electricity at unit distance apart.

Emergency Cable. A small, comparatively inexpensive and easily handled cable, employed in the case of breaks in a pole line due to floods, railroad wrecks, etc., for opening up communication during repairs of the break.

Emergency Switch. An accessory switch placed on a car controller for reversing the motion of a car when necessary.

Empanelled Wires. Wires placed inside mouldings, or behind panels.

Enamelled Rheostat. A rheostat whose coils consist of wires imbedded in a mass of enamel, in close juxtaposition to a mass of iron or other heat-conducting material.

Enamelled Wire. Wire having a very thin insulation of enamel.

Enclosed Arc-lamp. An arc-lamp whose carbons are enclosed by a closely fitting globe, so as to maintain an atmosphere around the arc practically devoid of oxygen, thus diminishing the rate of consumption of the carbons.

Endoscopic Lamp. A lamp provided for the examination of a bodily cavity through its natural outlet.

End-to-end Joint. A term frequently employed in place of butt-joint.

End Windings. End connections. Conductors for connecting up bar windings at the end of an armature.

Energy. The power of doing work.

Energy Component of Current. In an alternating-current circuit the component of current which is in phase with the impressed E.M.F. In an alternating-current circuit, the product of the E.M.F. and the effective conductance.

Energy Component of E.M.F. In an alternating-current circuit the component of E.M.F. which is in phase with the current. In an alternating-current circuit, the product of the current and the effective resistance.

Energy, Electric. The power which electricity possesses of doing work.

Energy Resistance. In an alternating-current circuit, the energy component of impedance.

Entrefer. The gap of non-magnetic material through which the field flux has to pass at the surface of the armature of a dynamo-electric machine, composed either of an air-gap or of air and copper. The width of the non-magnetic gap, as distinguished from the width of the clearance or simple air-gap of a smooth cored armature.

Equalizer. An equalizing bar. A term employed for an equalizer wire. A device for equalizing electric pressure over a system.

Equalizer Feeder. A feeder whose sole or principal purpose is to equalize the pressure between the ends of two or more other feeders, as distinguished from supplying current to feeding points.

Equalizing Current. The current passing through an equalizing bar between two dynamos.

Equalizing Dynamo. A dynamo employed in systems of three or five-wire distribution to supply one pair of mains which may be unduly loaded so as to equalize the pressure.

Equalizing Wires. Two wires or conductors one of which is employed for connecting the positive brushes and the other for connecting the negative brushes of compound-wound dynamos, when connected in parallel. Wires connecting corresponding segments in a multipolar armature winding.

Equipotential. Of or pertaining to an equality of potential.

Equivalent Conductivity. The molecular conductivity of a solution divided by the valency.

Equivalent Resistance. A single resistance which may replace a number of resistances in a circuit without alternating the current traversing it. Such a resistance in a simple-harmonic-current circuit as would permit energy to be absorbed,

Electrical Dictionary

with the same effective current strength, at the same rate as an actual resistance in a complex-harmonic-current circuit. The effective resistance of an alternating-current system or conductor.

Erg. The C.G.S. unit of work, or the work done when unit C.G.S. force is overcome through unit C.G.S. distance. The work accomplished when a body is moved through a distance of one centimetre with the force of one dyne. A dyne-centimetre.

Excitation. The production of electrification by any means. The production of magnetism by any means. The energizing of any electro or magneto-receptive device. The production of the magnetic field in a dynamo or motor. The stimulation of a muscle or nerve fibre.

Exciter Dynamo. A dynamo used for the separate excitation of another dynamo.

Expansion, Electric. The increase in volume produced in a body by giving it an electric charge.

Expansion Joint. A joint suitable for tubes or pipes exposed to considerable changes of temperature, in which a sliding joint is provided to safely permit a change in length on expansion or contraction.

Exploring Needle. A form of exploring probe. A magnetic needle employed in exploring a magnetic field.

External Characteristic of Dynamo. A curve showing the E.M.F. at the terminals of a dynamo under varying currents, as distinguished from an internal characteristic showing the internal E.M.F.

External Magnetic Field. That portion of a magnetic field which lies outside the body of a magnet.

Extra Currents. Currents produced in a circuit by self-induction.

Extra-polar. Lying beyond or outside the poles.

F.

𝔉 A symbol for magnetomotive force.

Fac-simile Telegraphy. A system whereby a fac-simile or copy of a chart, diagram, picture or signature, is telegraphically transmitted from one station to another. Pan-telegraphy.

Fahrenheit Thermometric Scale. The thermometric scale in which the length of the thermometer tube, between the melting point of ice and the boiling point of water, is divided into 180 equal parts or degrees.

Fall of Potential. The drop of potential.

False Resistance. A resistance arising from a counter electromotive force, and not directly from the dimensions of the circuit, or from its specific resistance.

Farad. The practical unit of electric capacity. Such a capacity of a conductor or condenser that one coulomb of electricity is required to produce therein a differencc of potential of one volt. (See International Farad.)

Faradic Current. In electro-therapeutics, a current produced by an induction coil, or magneto-electric machine. A rapidly alternating current, as distinguished from a direct current.

Faradic Machine. Any machine for producing faradic currents.

Fatigue of Iron or Steel, Magnetic. The change of magnetic hysteresis loss with time of service. Ageing of magnetic material.

Feed. To supply with an electric current. To move or regulate one of both of the carbon electrodes in an arc-lamp.

Feeder. An electric circuit, used to supply power to a station or service, as distinguished from circuits confined to a single station or used for other purposes than supplying power.

Feeder Distribution. A feeder-and-main system of distribution.

Feeding Point. A point of connection between a feeder and the mains. A feeding center.

Ferranti Effect. An increase in the electromotive force or difference of potential of mains or conductors carrying alternating currents, which exists towards the end of the same furthest from the terminals that are connected with the source. A negative drop in pressure.

Fibre Suspension. Suspension of a needle or other system by a fibre of unspun silk, quartz or other suitable material.

Fibre, Quartz. A fibre suitable for suspending galvanometer needles, etc., made of quartz.

The quartz fibre is obtained by fusing quartz and drawing out the fused material as a fine thread, in a manner similar to the production of glass fibres. Quartz fibres possess marked advantage over silk fibres, in that they are 5.4 stronger for equal diameters, and especially, in that they return to the zero point, after very considerable deflections.

Field. A term sometimes used for a magnetic field. A term sometimes used for an electrostatic field.

Field, Electrostatic. The region of electrostatic influence surrounding a charged body.

Field, Magnetic. The region of magnetic influence surrounding the poles of a magnet.

A space or region traversed by lines of magnetic force.

A place where a magnetic needle, if free to move, will take up a definite position, under the influence of the lines of magnetic force.

Field Magnets. The magnets which produce the magnetic field or flux in which the armature of a dynamo or motor rotates.

Field of Force. The space traversed by electrostatic or magnetic flux. An electrostatic or magnetic field.

Fish Plate. In a system of electric railroads, the plate connecting contiguous rails by bolts.

Fishing of Wires. The process of drawing a wire into its place in a building through floors, walls, or ceilings by placing a wire in a hole at one end engaging it by a hook from the other, so as to draw it through.

Fittings. The sockets, holders, arms, etc., required for holding and supporting incandescent electric lamps. Incandescent light fixtures.

Fixture, Electric. Fittings for electric light. A support or electrolier for one or more incandescent lamps rigidly fastened to a wall or ceiling. Any electric apparatus forming part of a permanent installation.

Fixture, Wire. A class of insulated wire suitable for use in electric fixtures. (See page 128.)

Flaming Arc Lamp. A recent type of arc lamp in which the two carbons or electrodes meet at a very oblique angle and the arc formed between them is arched downward. The electrodes used are composed of or charged with substances that give off at the temperature of the arc strongly illuminous vapors which serve as a source of light. The arc is formed in a shallow cup-like recess which becomes coated with the white calcium oxide fumes and serves as a very fair reflector. The electrodes carry the vapor-producing substance in various ways, usually in a relatively soft core, the arc is long, and is the chief, almost the sole source of light. This is said to be one of the much efficient sources of light.

Flaming of Carbon Arc. An irregular burning of a voltaic arc, which occurs when the carbons are too far apart, and the current strength somewhat exceeds the normal.

Flashing. Subjecting carbons to the flashing process.

Flashing of Dynamo-electric Machine. A name given to long flashing sparks at the commutator of a dynamo, due to the short-circuiting of the external circuit at the commutator.

Flat Rate. Method of charging for electric service only a fixed sum per month, or per annum, for a specified service, as supplying a certain number of outlets, or up to a certain maximum demand without reference to the quantity of electricity actually consumed.

Electrical Dictionary

Flats. Those parts of commutator segments, the surfaces of which, through wear or otherwise, have become lower than the other portions.

Flexible Cable. A stranded cable, or one which can be readily flexed or bent.

Flexible Lamp-cord. See Lamp Cord. (See Index.)

Flow, Electric. Electric current.

Flush Plate. A plate on which flush push-buttons are mounted.

Flux. Magnetic or electric flux. A surface integral of a vector quantity.

Flux Density. The quantity of magnetic flux per unit of area of normal cross-section.

Flux, Electric. Electrostatic flux.

Flux, Intensity. The density of a flux. The surface density of a vector quantity at a point.

Flux, Magnetic. The number of lines of magnetic force that pass or flow through a magnetic circuit. The total number of lines of magnetic force in any magnetic field.

Flux of Magnetism. The flow of magnetic induction. The surface integral of magnetic induction through a given surface.

Focusing Arc-lamp. An arc-lamp designed for use in connection with a reflector or lens, whose mechanism feeds both carbons, and so permits the arc to be maintained at the focus of the reflector or lens.

Foot-candle. A unit of illumination equal to the normal illumination produced by a standard candle at the distance of one foot.

Foot-pound. A unit of work. The amount of work required to raise one pound vertically through a distance of a foot.

Foot-pound-per-second. A unit of activity. A rate-of-doing work equal to the expenditure of one foot-pound per second.

Force, Electric. The force exerted between electrostatic charges.

Force, Electromotive. See Electromotive Force.

Form Factor of Alternating-current. A factor equal to the square root of the mean square divided by the true mean value of the alternating electro-motive force or current.

Formers. The forms employed in obtaining formed armature or other windings.

Forward Lead of Dynamo Brushes. A displacement of the brushes on the commutator of a dynamo in the direction of rotation of the armature.

Foucault Currents. A name sometimes applied to eddy currents, especially when in armature cores. Useless currents developed in a conducting mass, through which varying magnetic flux is moving.

Fountain, Electric. A fountain operated by electric motors, provided with a variety of jets that are electrically illumined by different colored lights.

Four-point Switch. A switch whose circuit can be completed through four points, either singly or simultaneously. A four-pole switch.

Four-wire System. A system similar to its general arrangement to the three-wire system, in which three dynamos are connected to four wires or conductors.

Fractional Electrolysis. Successive electrolysis of different substances by gradually raising the E.M.F.

Free Charge. The condition of an electric charge on a conductor isolated from other conductors.

Free Magnet Pole. A pole in a piece of iron or other paramagnetic substance which acts as if it existed as one magnetic pole only.

French Standard Candle. The bougie-decimale or the twentieth part of a Violle.

Frequency of Alternation. The number of cycles or periods executed by an alternating current in unit time. The periodicity. The two standard frequencies are now 25 and 60.

Frequency Changer. A piece of apparatus for changing from one frequency to another, consisting of a motor driving either an ordinary alternating-current generator or a machine constructed like an induction motor In the former case the term is to be preceded by the words "motor generator," and in the latter case by the word "induction."

Frequency Converter. A machine for converting from an alternating-current system of one frequency to an alternating-current system of another frequency.

Frequency Setter. In an alternating-current circuit having induction machines, an alternator which supplies them with a definite frequency.

Frictional Electricity. The electricity developed by friction.

Frog. A metallic guide placed on one side of a single track, where a car has to be driven from one track to another, so as to guide the car in the required direction. A grooved piece of metal, serving as a guide, at the intersection of two rails in a track-crossing. A trolley frog.

Full-load Efficiency of Motor. The efficiency of a motor when operating at full load.

Fundamental Frequency. The nominal or lowest frequency of a complex harmonic electromotive force, flux or current.

Fundamental Units. The units of length, time, and mass, to which all other quantities can be referred. Units of length, time and mass, as distinguished from their derivations, or derived units.

Furnace, Electric. A furnace in which electrically generated heat is employed for effecting difficult fusions, for the extraction of metals from their ores, or for other metallurgical operations.

Fuse Block. A block containing a safety fuse or fuses.

Fuse Box. A box containing a safety fuse. A box containing fuse wires.

Fuse, Electric. A conductor designed to melt or fuse at a certain value of current and time and by so doing to rupture the circuit.

Fuse Links. Strips or plates of fusible metal in the form of links employed for safety fuses.

Fusing Current.—A term sometimes applied to the current which causes a fuse to blow or melt.

G.

g. An abbreviation or symbol for the gravitation constant, or the force with which the earth acts upon unit mass at any locality. An abbreviation proposed for gramme, the unit of mass in physical investigations.

Gains. The spaces cut in the faces of telegraph poles for the support and placing of the cross arms.

Galvanic Battery. An unadvisable term sometimes used in place of voltaic battery.

Galvanizing. Covering iron with an adherent coating of zinc by dipping it in a bath of molten metal. Subjecting a nerve or muscle to the action of galvanism. (See Index.)

Galvanometer. An apparatus for measuring the strength of an electric current by the deflection of a magnetic needle. A current measurer.

The galvanometer depends for its operation on the fact that a conductor, through which an electric current is flowing, will deflect a magnetic needle placed near it. This deflection is due to the magnetic field caused by the current.

The needle is deflected by the current from a position of rest, either in the earth's magnetic field or in a field obtained from a permanent or an electro-magnet. In the first case, when in use to measure a current, the plane of the galvanometer coils must coincide with the planes of the magnetic meridian. In the other case, the instrument may be used in any position in which the needle is free to move.

Galvanometers assume a variety of forms according either to the purposes for which they are employed, or to the manner in which their deflections are valued.

Galvanometer Constant. The constant of calibration of the galvanometer scale. The numerical factor connecting a current passing through a galvanometer with the deflection produced by such current. The value of one division of the galvanometer scale in terms of resistance or current strength.

Galvanometer Shunt. A shunt placed around a sensitive galvanometer in order to protect it from the effects of a strong current, or for reducing its sensibility.

Galvanoscope. A galvanometer intended to show the existence of a current rather than to measure its strength. A crude or simple form of galvanometer.

Gap Space. The air-gap or entrefer.

Gassing. The evolution of gas from the plates of a secondary or storage battery.

Gauss. The name proposed in 1894 by the American Institute of Electrical Engineers for the C.G.S. unit of magnetic flux density. A unit of intensity of magnetic flux, equal to one C.G.S. unit of magnetic flux per-square-centimetre of area of normal cross-section. A name proposed for the C.G.S. unit of magnetic potential or magnetomotive force by the British Association in 1895.

Geissler Tubes. Glass tubes, provided with platinum electrodes passed through and fused into the glass, containing the residual atmospheres of gases at a comparatively low vacuum, either with or without fluorescent liquids, or solids, or both, employed to obtain various luminous effects on the passage of electric discharges.

Gem Lamp. An incandescent lamp using a carbon filament, which has a positive temperature coefficient or resistance.

Generator. A dynamo-electric machine. One which transforms mechanical into electrical power.

German-silver Alloy. An alloy, employed for the wires of resistance coils, usually consisting of fifty parts of copper, twenty-five of zinc and twenty-five of nickel.

Gilbert. A name proposed for the C.G.S. unit of magnetomotive force. A unit of magnetomotive force equal to that produced by $\frac{1}{1.2566}$ of one ampere-turn.

Globe Strain-insulators. Insulators provided for the support of the strain wires in an overhead trolley system.

Glow-lamp, Electric. A lamp whose light is produced by glow illumination. A term sometimes used for incandescent lamps.

Goose-neck Pull-off. An insulator, with a support shaped like a goose neck, employed on curves to hold the trolley wire in position, and provided with a single point for the attachment of the strain wire.

Gradient, Electric. The rapidity of increase or decrease of the strength of an electromotive force or current. The vector space-rate of descent of electric potential at any point.

Gramme. A unit of mass equal to 15.43235 grains. The mass of a cubic centimetre of water at the temperature of its maximum density.

Gramme Armature-winding. The winding originally employed by Gramme on the armature of his dynamo-electric machine.

Gramme-calorie. The amount of heat required to raise a gramme of water one degree Centigrade. The gramme-degree-Centigrade.

Gramme-ring Transformer. A transformer whose primary and secondary coils are placed on a closed iron ring. A transformer resembling a Gramme-ring armature.

Graphite. A variety of soft carbon suitable for writing on paper or on similar surfaces.

Graphite is used for rendering surfaces to be electro-plated, electrically conducting, and also for the brushes of dynamos and motors. For the latter purpose it possesses the additional advantage of decreasing the friction by means of its marked lubricating properties.

Gravity Ammeter. A form of ammeter in which the magnetic needle is moved against the force of gravity by the magnetic influence of the current it is measuring.

Gravity Voltmeter. A form of voltmeter in which the potential difference is measured by the movement of a magnetic needle against the pull of a weight.

Grid. A lead plate provided with perforations or other irregularities of surface, and employed in storage cells for the support of the active material. The support provided for the active material on the plate of a secondary or storage cell.

Ground. A general term for the earth when employed as a return conductor.

Ground Circuit. A circuit in which the ground forms part of the path through which the current passes.

Ground Detector. In a system of incandescent lamp distribution, a device placed in a central station for indicating, by the brightness of a lamp, the existence of a ground on the system. An instrument for detecting or measuring grounds or leaks.

Ground-return. A general term used to indicate the use of the ground or earth for part of an electric circuit. The earth or ground which forms part of the return path of an electric circuit.

Ground Wire. The wire or conductor leading to or connected with the ground or earth in a grounded circuit.

Grounding. A word sometimes employed in electro-metallurgy for the preparatory process of burnishing. Connecting a circuit to earth or ground.

Grove's Voltaic Cell. A zinc-platinum couple immersed respectively in electrolytes of sulphuric and nitric acid.

Guard Wire. A wire hung above any active conductor, such as a trolley wire in order to prevent it from coming into electric contact with falling wires.

Gutta-percha. A resinous gum obtained from a tropical tree, and valuable electrically for its high insulating powers and for its indestructibility when employed in sub-marine cables.

Guy. A rod, chain, rope, or wire employed for supporting or stiffening any structure such as a telegraph pole.

Guy Wire. A wire employed as a guy.

H.

H. A contraction for the henry or practical unit of self induction.

$\mathcal{H}$ A contraction for the magnetizing force that exists at any point, or, generally for the intensity of magnetic force.

H. A symbol for field intensity.

"H.B." Curves. Curves indicating the relations between magnetizing force and magnetic flux density in a magnetic substance. A term sometimes employed for magnetization curves.

H.P. A contraction for horse-power.

Hall Effect. A transverse electromotive force produced by a magnetic field in substances undergoing electric displacement.

Hanger Board. A form of board provided for the ready replacement or removal of an arc-lamp from a circuit.

Hard-drawn Copper Wire. Copper wire that is hardened by being drawn three or four times without annealing. Copper wire not annealed after leaving the die. (See Index.)

Harmonic Currents. Periodically alternating currents varying harmonically. Currents which are harmonic functions of time. Sinusoidal currents.

Head of Liquid. The vertical distance from the level of a liquid in a containing vessel to the center of gravity of an orifice placed therein. Difference of liquid elevation or level.

Electrical Dictionary

Heat. A form of energy. A mode of motion. A vibratory motion impressed on the molecules of matter by the action of any form of energy. A wave motion impressed on the universal ether by the action of some form of energy.

Heat Unit. The quantity of heat required to raise a unit mass of water through one degree of the thermometric scale. The calorie. There are a number of different heat units. The most important are:

The British Heat Unit, or Thermal Unit, or the amount of heat required to raise 1 pound of water 1 degree Fahr. This unit represents an amount of work equal to 772 foot pounds.

The Greater Calorie, or the amount of heat required to raise the temperature of 1,000 grammes of water 1 degree C.

The Smaller Calorie, or the amount of heat required to raise the temperature of one gramme of water 1 degree C.

The Joule, or the quantity of heat developed in one second by the passage of a current of one ampere through a resistance of one ohm.

1 joule equals .0002407 large calories.
1 joule equals .2407 small calories.
1 foot-pound equals 1.356 joules.

Hefner. See Candle-Lumen.

Hekto. A prefix for one hundred.

Helicon Lamp. An incandescent lamp having a carbon filament treated with a volatile silicon compound instead of the usual hydro-carbon gases.

Henry. The practical unit of self-induction. An earth-quadrant, or 10^9 centimetres. (See International Henry.)

Hertzian Waves. Electro-magnetic waves given off by an electro-magnet whose intensity is undergoing rapid periodic variations, or by a current whose strength is undergoing rapid periodic variations. Electro-magnetic waves given off from a circuit through which an oscillatory discharge is passing.

Hewitt's Mercury Arc Lamp. In this form of lamp there is an arc formed between mercury electrodes or metallic terminal and mercury electrode in a long exhausted tube, the arc being usually struck by tilting the tube so that the current follows the trickling mercury. Once thus formed the mercury vapor maintains a very steady and powerful glow under the electric discharge which it permits.

High Frequency. A frequency so high that Ohm's Law does not apply even approximately.

High-potential Current. A term loosely applied for a current produced by high electromotive forces.

High-potential Insulator. An insulator suitable for use on high-potential circuits.

High-tension Circuit. A circuit employed in connection with high electric pressures.

Hittorf Tubes. Various forms of high-vacuum tubes employed by Hittorf in his researches in electrical discharges through high vacua.

Holophane. A form of glass globe or enclosing chamber for a source of light, which has its external surface cast into lenticular ridges for the more general diffusion of the emerging light.

Holtz Influence Machine. A particular form of electrostatic influence machine.

Homopolar Dynamo. A dynamo whose conductor moves continuously past poles of one polarity only. A commutatorless dynamo. A so-called unipolar dynamo.

Horizontal Candle Power. The intensity of light emitted by any source in a horizontal direction. The luminous intensity of a source taken in a horizontal direction, as measured in units of luminous intensity.

Horizontal Component. That portion of a force which acts in a horizontal direction.

Horizontal Intensity of Light. The intensity of a light measured in a horizontal direction.

Horse-power. A commercial unit of power, activity, or rate-of-doing-work. A rate-of-doing-work. A rate-of-doing-work equal to 33,000 pounds raised one foot-per-minute, or 550 pounds raised one foot-per-second. A rate-of-doing-work equal to 4,562 kilograms raised one metre per minute.

Horse-power, Electric. Such a rate-of-doing electrical work as is equal to 746 watts, or 746 volt-coulombs per second.

Horse-power-hour. A unit of work equal to the work done by one horse-power acting for an hour. 1,980,000 foot-pounds.

Horseshoe Magnet. A magnetized bar of steel or hardened iron, bent in the form of a horse-shoe, or letter U.

Hot-wire Voltmeter. A voltmeter whose indications are based on the increase in the length of a metallic wire placed in the circuit of the electromotive force that is to be measured.

House Mains. The conductors connecting the service wires with the street mains, in a system of multiple incandescent lamp distribution.

Hummer, Electric. A word sometimes employed for an electric buzzer.

Hunting of Parallel-connected Alternators. A periodic increase and decrease in the speed of alternators, when running under certain conditions in parallel connections as motors or dynamos. Imperfect synchronous running.

Hydro-electric System. An electric system with generator driven by water-power.

Hysteresis. A lagging behind of magnetization relatively to magnetizing force. Apparent molecular friction due to magnetic change of stress. A retardization of the magnetizing or demagnetizing effects as regards the causes which produce them. That quality of a paramagnetic substance by virtue of which energy is dissipated on the reversal of its magnetization.

Hysteresis Coefficient. The hysteretic coefficient. The energy dissipated in a cubic centimetre of magnetic material by a single cyclic reversal of unit magnetic density.

Hysteretic Cycle. A cycle of complete magnetization and reversal.

Hysteretic Lag. The lag in the magnetization of a transformer due to hysteresis.

I.

I. A symbol for strength of current.

𝔏. A symbol for inductance.

I.H.P. A contraction for indicated horse-power.

I^2R. Activity. The activity expended in a circuit, equal to the square of the current strength in amperes by the resistance in ohms. The C^2R activity.

I^2R. Loss. The loss of power in any circuit equal to the square of the current in amperes by the resistance in ohms. The C^2R. loss.

Idle Coil. Any coil through which for the time no current is passing. Any coil which is not passing through a magnetic field or generating an E.M.F.

Idle Current of Alternating-current Dynamo. The wattless current of an alternating-current circuit, as distinguished from the active or working current.

Impedance. Generally, opposition to current flow. The sum of the ohmic resistance, and the spurious resistance of a circuit, measured in ohms. In a simple-harmonic current circuit the square root of the sum of the squares of the resistance and reactance. The apparent resistance of a circuit containing both resistance and reactance. (See Alternating Currents.)

Impedance Circuit. A circuit containing impedance.

Impedance Coils. A term sometimes applied to choking coils, reactance coils, or economy coil.

Impedance Rush. The rush of current produced on closing an inductive circuit. An impulsive current rush.

Impressed Electromotive Force. The electromotive force brought to act in any circuit to produce a current therein. In an alternating-current circuit, the impressed electromotive force due to an impressed source, in contradistinction to the effective electromotive force, or that which is active in producing current, or the electromotive forces due to, or opposed to, self or mutual induction. An applied E.M.F. as distinguished from a resultant, active or wattless E.M.F.

Impulsive Inductance. The apparent inductance of a conductor or circuit when subjected to an impulsive discharge.

Incandescence, Electric. The shining or glowing of a substance, generally a solid, by means of heat of electric origin.

Incandescent Filament. The incandescing conductor of an incandescent electric lamp, whether of small or of comparatively large cross-section, though generally of the former.

Incandescent Electric Lamp. An electric lamp whose light is produced by the electric incandescence of a strip or filament of some refractory substance, almost invariably carbon.

India Rubber. A resinous substance obtained from the milky juices of a tropical tree. Caoutchouc. (See Index, Rubber.)

Indicator, Electric. A general term applied to various devices operated by the deflection of a magnetic needle, or the ringing of a bell, or by both, for indicating at some distant point, the condition of an electric circuit, the strength of current passing through any circuit, the head of water or other liquid, the pressure on a boiler, the temperature, the speed of an engine or lines of shafting, the working of a machine, or other similar events or occurrences. A term sometimes used in place of annunciator. Any electric or magnetic signalling apparatus.

Induced. Set up or caused by induction. Not produced by metallic communication.

Induced Current. A current produced by electrodynamic induction.

Induced Electromotive Forces.—E.M.F.'s set up by electro-dynamic induction.

Induced M.M.F. Any magnetomotive force produced by induction. The aligned or structural magnetomotive force as distinguished from the prime magnetomotive force.

Inductance. The capacity for induction possessed by an active circuit on itself, or on neighboring circuits. Self-induction. That property, in virtue of which a finite electromotive force impressed on a circuit does not immediately generate the full current due to the resistance of the circuit, and which, when the electromotive force is withdrawn, requires a finite time for the current strength to fall to its zero value. A property, by virtue of which the passage of an electric current is necessarily accompanied by the absorption of electric energy in producing a magnetic field. A constant quantity in a circuit at rest, and devoid of iron, depending only upon its geometrical arrangement, and usually expressed in henrys, or in centimetres.

Inductance Coil. An impedance, reactance, or choking coil. A coil placed in a circuit, for the purpose of preventing an impulsive current-rush in that circuit, by means of the counter-electromotive force developed in the coil on being magnetized.

Inductanceless Circuit. A circuit practically devoid of inductance. A circuit whose magnetic field is negligible, such, for example, as an ordinary incandescent lamp, or a double-wound resistance coil.

Induction. The influence exerted by a charged body or by a magnetic field, on neighboring bodies without apparent communication. The influence produced through a dielectric by the action of electrostatic or magnetic flux

Induction Coil. An apparatus consisting of two associated coils of insulated wire employed for the production of currents by mutual induction.

Induction Generator. A machine similar to the induction motor, but driven as an alternating-current generator.

Induction, Magnetic. The production of magnetism in a magnetizable substance by bringing it into a magnetic field.

Induction, Mutual. Induction produced by two neighboring circuits on each other by the mutual interaction of their magnetic fields.

Induction Screen. A plate of metal placed between two adjacent electrified bodies, or magnetic coils, for the purpose of preventing or modifying the inductive action they exert on one another. A conducting screen wholly or partially opaque to inductive action.

Induction, Self. Induction produced in a circuit at the moment of starting or stopping the currents therein by the induction of the current on itself.

Induction Starter. A device used in starting induction motors, converters, etc., when they are started by voltage control, consisting of an auto-transformer in connection with a suitable switching device.

Inductive Circuit. Any circuit in which induction occurs.

Inductive Disturbance. Any disturbance in the operation of a telephone or telegraph line produced by induction.

Inductive Reactance. Reactance due to self induction as distinguished from reactance due to a condenser.

Inductive Resistance. A resistance possessing self-induction. The reactance of a circuit.

Inductor Alternator. An alternating-current generator in whose armature windings the field magnetic flux pulsates but never reverses.

Influence, Electric. Electrostatic induction.

Influence Machine. A name sometimes used for an electrostatic-induction machine.

In-put. The power absorbed by any machine in causing it to perform a certain amount of work.

Inside Wiring. In a system of incandescent lighting, the conductors that lead to the interior of a house or other building to be lighted. Any conductors placed inside a building.

Installation. A general term embracing the entire plant and accessories required to perform any specified work. The act of placing, arranging or erecting a plant or apparatus.

Instantaneous Peak. The highest value reached by the quantity under consideration as measured by some device which indicated high actual value of the quantity at every moment.

Insulate. To so cover or protect a body as to prevent electricity from being conducted to or removed from it.

Insulated Wires. Wires provided with insulating coverings or coatings. (See Index.)

Insulating Joint. A joint in an insulating material or covering in which the continuity of the insulating material is ensured.

Insulating Tape. A ribbon of flexible material impregnated with rubber, or other similar material, and generally containing some adhesive substance, employed for insulating wires or electric conductors at joints, or other exposed places.

Insulating Varnish. An electric varnish formed of any good insulating material.

Insulation Resistance. The resistance existing between a conductor and the earth or between two conductors in a circuit through insulating materials lying between them. A term applied to the resistance of the insulating material of a covered wire or conductor to an impressed voltage tending to produce a leakage of current. The resistance of any insulation.

Electrical Dictionary

Insulator, Electric. A body or substance which offers such resistance to the passage of electric current that it is used to prevent the passage of current. Any device employed for insulating a wire or other body.

Insulator Pin. The bolt by which an insulator is attached to a bracket, polearm, or support.

Intake of Machine. The activity required to operate a machine.

Intensified Arc Lamp. A term used for an arc lamp, with one of the carbons of small diameter to give a large current density per unit of arc, on which the arc plays to thereby intensify the light.

Intensity of Field. The strength or density of a magnetic field as measured by the quantity of magnetic flux that passes through it per-unit-of-area of normal cross-section.

Intensity of Magnetic Flux. The quantity of magnetic flux per-unit-of-area of normal cross-section. The density of magnetic flux.

Interior Conduit. A conduit provided inside the walls of a house, or in other convenient spaces within a house, for the reception of the house wires. A conduit in the walls or floors of a building, provided for accommodating electric conductors.

Intermittent Current. A current that does not flow continuously, but which flows and ceases to flow at intervals, so that electricity is practically alternately present and absent from the circuit.

Internal Characteristic of Dynamo. A curve showing the E.M.F. generated in a dynamo under varying excitation, as distinguished from the external characteristic showing the E.M.F. at terminals.

Internal Circuit. That part of a circuit which is included within the electric source.

Internal Poles of Dynamo. The inwardly projecting field poles of a dynamo. Magnetic field-poles internal to an armature.

International Ampere. The value of the ampere as adopted by the International Congress of 1893, at Chicago. The value of an ampere equal to the one-tenth of a unit of current in the C.G.S. system of electro-magnetic units, and represented with sufficient accuracy for practical purposes, by the unvarying current, which, when passed through a solution of nitrate of silver in water, in accordance with certain specifications, deposits silver at the rate of 0.001118 of a gramme-per-second.

International Coulomb. The value of the coulomb as adopted by the International Electrical Congress of 1893, at Chicago. The quantity of electricity equal to that transferred through a circuit by a current of one International ampere in one second.

International Farad. The value of the farad as adopted by the International Electrical Congress of 1893, at Chicago. The capacity of a conductor charged to a potential of one International volt by one International coulomb of electricity.

International Henry. The value of the henry as adopted by the International Electrical Congress of 1893, at Chicago. The value of the induction in a circuit, when the electromotive force induced in the circuit is one International volt, and the inducing current varies at the rate of one ampere per second.

International Joule. The value of the joule as adopted by the International Electrical Congress of 1893, at Chicago. A value equal to 10^7 units of work of the C.G.S. system and represented with sufficient accuracy for practical purposes by the energy expended in one second by one ampere in one International ohm.

International Morse Code. A term sometimes employed for the International telegraphic alphabet, as distinguished from the American Morse Code.

International Ohm. The value of the ohm as adopted by the International Electrical Congress of 1893, at Chicago. A value of the ohm equal to 10^9 units of resistance of the C.G.S. system of electro-magnetic units, and represented by the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice, 14.4521 grammes in mass, of a constant cross-sectional area, and of the length of 106.3 centimetres.

International Volt. The value of the volt as adopted by the International Electrical Congress of 1893, at Chicago. Such an electromotive force that steadily applied to a conductor whose resistance is one International ohm will produce a current of one International ampere, and which is represented with sufficient accuracy for practical use by $\frac{1000}{1434}$ of the electromotive force between the poles or electrodes of the voltaic cell known as Clark's cell, at a temperature of 15° Cent. when prepared in accordance with certain specifications.

International Watt. The value of the watt as adopted by the International Electrical Congress of 1893 at Chicago. A value equal to 10^7 units of activity in the C.G.S. system, and equal to the work done at the rate of one joule-per-second.

Interrupter. Any device for interrupting or breaking a circuit.

Ions. The groups of atoms or radicals into which a molecule is separated by electrolytic decomposition.

Ionic Conductivities. Specific conductivities of ions, so selected that their sums give molecular conductivities for any combination of ions.

Iron-armored Conduit. A conduit provided with an exterior iron casing or covering. A conduit in which each duct has an iron casing or covering.

Iron-clad. Protected or covered with iron.

Iron-clad Armature. The armature of a dynamo or motor, whose insulated coils are entirely or nearly surrounded by the iron of the armature core. An armature in which the conductors are buried in slots, grooves, or tunnels below the surface of the armature core.

Iron-core. The mass of iron on which are placed the magnetizing coils of an electro-magnet or solenoid.

Iron-core-loss. The hysteretic and Foucault losses due to the presence of an iron core.

Irreciprocal Conduction. Conduction in which the magnitude of the current is altered when its direction is reversed. The electric conduction in an assymmetrical resistance.

Isotropic Dielectric. A dielectric possessing the same powers of inductive capacity in all directions

J.

Jack Panel. The panel of a telephone switchboard provided for the support of the jacks.

Jack Switch. A switch operated by means of a spring jack.

Jacobi's Law. The maximum activity is performed by an electric motor when its counter-electromotive force is equal to one-half of the impressed electromotive force.

Joint Reluctance. The combined reluctance of a number of parallel-connected reluctances.

Joint Resistance. The combined resistance of a number of parallel-connected resistances.

Joule. A volt-coulomb or unit of electric energy or work. The amount of electric work required to raise the potential of one coulomb of electricity one volt. Ten million ergs. (See International Joule.)

Joule Effect. The heating effect produced by the passage of an electric current through a conductor, arising from its resistance only.

Joule's Equivalent. The mechanical equivalent of heat.

Joule's Law. The heating power of a current is proportional to the product of the square of its strength and the resistance of the circuit through which it passes

Electrical Dictionary

Jumper. A temporary shunt or short circuit put around a source, lamp or receptive device on a series-connected circuit, to enable it to be readily removed or repaired.

Jump Spark. A disruptive spark obtained between two opposed conducting surfaces, as distinguished from a spark obtained by or following a wiping contact.

Junction Box. A moisture-proof box provided in a system of underground conductors to receive the terminals of the feeders, and in which connection is made between the feeders and the mains, and through which the current is distributed to the individual consumers.

K.

K.W. A contraction for kilowatt.

kg. An abbreviation for kilogramme, a practical unit of mass.

kgm. An abbreviation for kilogramme-metre, a practical unit of the moment of a couple or of work.

Kaolin. A variety of white clay sometimes employed for insulating purposes.

Kick of Coil. The discharge from an electromagnetic coil.

Kicking Coil. A choking coil.

Kilo. A prefix for one thousand times.

Kilo-volt. One thousand volts.

Kilo-watt. One thousand watts.

Kilo-watt-hour. The amount of work equal to that performed by an activity of one kilowatt maintained steadily for one hour. An amount of work equal to 3,600,000 joules.

Knife-switch. A switch which is opened or closed by the motion of a knife contact between parallel contact plates. A knife-edge switch or knife switch.

L.

L. A symbol for coefficient of inductance.

L,l A contraction for length.

Lag. Falling behind. To fall behind.

Lagging Current. A periodic current lagging behind the impressed electromotive force which produces it.

Laminated Core. An iron core that has been subdivided in planes parallel to its magnetic flux-paths, in order to avoid the injurious production of Foucault or eddy currents.

Lamination. The sub-division of an iron core into laminae.

Lamp, Arc, Electric. See Arc Lamp, Electric.

Lamp Bulb. The chamber or globe in which the filament of an incandescent lamp is placed.

Lamp Circuit. A circuit containing an electric lamp or lamps.

Lamp Cord. A flexible cord containing two separately insulated wires suitable for use in connection with an incandescent lamp. (See Index.)

Lamp Dimmer. A reactive coil, employed on an alternating circuit for the purpose of varying the intensity of incandescent lights connected with such circuit.

Lamp Efficiency. Commonly, but illogically the watts consumed by a lamp per candle-power delivered. More nearly correctly the reciprocal of this; or the number of candles obtained from an incandescent lamp per watt supplied to it.

Lamp Filament. The filament of an incandescent lamp.

Lamp-hour. Such a service of electric current as is required to maintain one electric lamp during one hour. Such a quantity of electricity, or of electric energy as will maintain one standard lamp in normal operation for one hour.

Lap Joint. The joint effected by over-lapping short portions near the ends of the things to be joined, and securing them to each other while in that position. A joint between the ends of two conducting wires in which the two ends after being laid together, side by side, are lapped firmly together by a piece of separate wire.

Lap Winding. A winding for a drum armature in which the successive conducting loops are arranged on the surface of the armature overlapping one another.

Law of Ohm. The law of non-varying current strength in a circuit not subject to variation. Ohm's law. The strength of a continuous current is directly proportional to the difference of potential or electromotive force in the circuit and inversely proportional to the resistance of the circuit, i. e., is equal to the quotient arising from dividing the electromotive force by the resistance.

Ohm's law is expressed algebraically thus:

$$I = \frac{E}{R}; \text{ or } E = IR; \text{ or } R = \frac{E}{I}$$

If the electromotive force is given in volts, and the resistance in ohms, the formula will give the current strength directly in amperes.

The current in amperes is equal to the electromotive force in volts divided by the resistance in ohms.

The electromotive force in volts is equal to the product of the current in amperes and the resistance in ohms.

The resistance in ohms is equal to the electromotive force in volts divided by the current in amperes.

The quantity of electricity in coulombs is equal to the current in amperes multiplied by the time in seconds.

Lay. The helical disposition of wires in a strand or sheath, in which each wire makes a complete revolution about the axis.

Lead. A very malleable and ductile metal of low tenacity and high specific gravity. Tensile strength 1600 to 2400 per square inch. Elasticity very low, and the metal flows under a very slight strain. Lead dissolves to some extent in pure water, but water containing carbonates or sulphates forms over it a film of insoluble salt which prevents further action. Atomic weight 206.9. Specific gravity 11.07 to 11.44. Melts at about 625 F.°; softens and becomes pasty at 617° F. (Kent).

Lead-encased Cable. A cable provided with a sheathing or coating of lead on its external surface. (See Index.)

Lead of Current. An advance in the phase of an alternating current beyond that of the electromotive force producing the current.

Lead of Motor Brushes. The angular displacement from the normal position in the direction contrary to that of the rotation of the armature, which it is necessary to give the brushes on an electric motor, when its load is increased, in order to obtain freedom from sparking.

Lead Sheathing. The coating of lead placed on the outside of a lead-covered cable.

Lead Sleeve. A lead tube provided for making a joint in a lead-covered cable.

Leading Current. An alternating-current wave or component, in advance of the electromotive force producing it.

Leading-in Wires. The wires that pass from an aerial circuit into a house or building. The wires or conductors which lead the current through an incandescent electric lamp; i. e., into and out of a lamp. Wires leading a circuit into a house, room, box or apparatus.

Leads. In a system of parallel distribution, the conductors connected to the positive and negative terminals of a source. Conductors which lead the current to or from any source, circuit or device. In electric testing the insulating conductors leading the testing current to the circuit or conductor tested.

Electrical Dictionary

Leak. Any loss or escape by leaking.

Leakage Current of Primary. The magnetizing current which flows into the primary circuit of a a transformer when the secondary circuit is open. A current employed in magnetizing only, as distinguished from a current usefully transformed.

Leakage Factor. In a dynamo-electric machine, the ratio of the total flux which passes through the field-magnet cores of a dynamo or motor, to the total useful flux passing from them through the armatures.

Leakage Reactance. That portion of the reactance of any induction apparatus which is due to stray flux.

Left-handed Winding. The winding of a solenoid or helix in a counter-clockwise direction.

Leg of Circuit. A branch of a bifurcated or divided circuit. A loop or offset in a series circuit

Legal Ohm. See International Ohm, and Ohm.

Lenz's Law. In all cases of induction the direction of the induced current is such as to oppose the motion which produces it.

Leyden-jar. A condenser in the form of a jar, in which the metallic coatings are placed opposite each other respectively on the outside and inside of the jar.

Light. That particular form of radiant energy by means of which objects are rendered visible. The flow or flux of light emitted from a luminous source.

Lightning Arrester. A device by means of which the apparatus placed in any electric circuit is protected from the destructive effects of a flash or discharge of lightning.

Lightning Bolt. A lightning flash or discharge.

Lightning Rod. A rod, strap, wire or stranded cable, of good conducting material, placed on the outside of a house or other structure, in order to protect it from the effects of a lightning discharge.

Line Circuit. The wires or other conductors in the main line of a telegraphic or other circuit. A transmission circuit for electric energy.

Line Drop. In a telephone switchboard, an electro-magnetic drop connected to a line.

Lines of Force. Lines of magnetization.

Lines of Magnetization. A term sometimes applied for lines of magnetic induction. A term sometimes applied to those portions of the lines of magnetic force which lie within the magnetized substance.

Linear Capacity. The quotient of the capacity of a line or conductor by its length.

Link-fuse. A link-shaped leaden plate, provided with suitable ends for connection with the copper fuse-wire terminals.

Listening Cam. In a telephone system a metallic cam or lever-key by means of which an operator readily places her telephone in circuit with a subscriber.

Live Wire. A wire through which current is passing. A wire connected with an electric pressure or source.

Load. The work thrown on any machine.

Load-factor. The fraction expressed in per cent. obtained by dividing the average load over any given period of time by the highest average load for any one minute during the same period of time.

Load-factor Rate. A rate based on load-factor.

Local Currents. A term sometimes used for eddy currents.

Lock, Electric. A lock that is automatically released by the aid of a distant push-button.

Locomotive, Electric. A locomotor whose motive power is electricity. An electrically driven locomotive engine.

Lodestone. A name given to a piece of naturally magnetized iron ore.

Log, Electric. An electric device for measuring the speed of, or the distance traversed by, a vessel.

Logarithm. The exponent, or the power to which it is necessary to raise a fixed number called the base, in order to produce a given number.

Long-distance Transmission. Transmission of electric energy over fairly considerable distances.

Loop Test. A localization test for a fault in a loop of two telegraphic wires, or in a complete metallic circuit.

Low-potential System. In the National Electric Code a system having a pressure less than 550 and more than 10 volts.

Low-pressure Circuit. A circuit designed for use in connection with low electric power.

Low Tension. A relative term used to designate a winding or conductor of less voltage than that with which it is related or compared.

Luminous Efficiency. The ratio which the luminous radiation emitted by a source bears to the total radiant energy emitted by such source in a given time.

Luminous Radiation. Radiation capable of affecting the eye.

M.

m. A symbol for strength of magnetic pole.

m. An abbreviation for metre, a practical unit of length.

M,m. An abbreviation for mass.

μ. A symbol for magnetic permeability or inductivity.

mm. A contraction for millimetre.

M.M.F. A contraction for magnetomotive force.

Machine Telegraphy. Automatic or high-speed telegraphy.

Magnet. Any body producting magnetic flux. A body possessing the power of attracting the unlike pole of another magnet, or of repelling the like pole, or of inducing magnetism in magnetizable bodies.

Magnet Coil. A coil of insulated wire surrounding the core of an electro-magnet, through which the magnetizing current is passed.

Magnet Cores. Bars or cylinders of iron on which the magnetizing coils of wire are placed.

Magnetic Air-gap. Any gap in an aero-ferric magnetic circuit filled with air.

Magnetic Attraction. The mutual attraction exerted between unlike magnetic poles.

Magnetic Axis. The line along which a magnetic needle, free to move, but which has come to rest in a magnetic field, can be turned without changing the direction in which it comes to rest. The line connecting the poles of a bar magnet or needle.

Magnetic Circuit. The path through which magnetic flux passes.

Magnetic Clutch. A form of clutch in which magnetic attraction is substituted for ordinary mechanical force, to obtain the friction required in the clutch. A clutch operated electro-magnetically.

Magnetic Couple. The couple which turns or tends to turn a magnetic needle, placed in the earth's field, into the plane of the magnetic meridian.

Magnetic Density. The strength of magnetism as measured by the amount of magnetic flux which passes through unit area of normal cross-section. Intensity of magnetic induction.

Magnetic Dip. The deviation of a freely suspended magnetic needle from a true horizontal position. The magnetic inclination.

Magnetic Fatigue. An increase in the hysteretic coefficient of iron due to an assumed fatigue after many cyclic reversals.

Magnetic Field. The region of magnetic influence surrounding the poles of a magnet. The space or region traversed by magnetic flux in which a magnet needle, free to move, will assume a definite position.

Magnetic Flux. The streamings that issue from and return to the poles of a magnet. The total number of lines of magnetic force in any magnetic field. The magnetic flow that passes through any magnetic circuit.

Magnetic Flux=paths. Paths taken by magnetic flux in any magnetic circuit.

Magnetic Force. The force which causes the attractions and repulsions of magnetic poles.

Magnetic Hysteresis. See Hysteresis.

Magnetic Induction. In air, the density of magnetic force; in iron or other magnetic material the sum of the prime flux, or magnetic force, and the magnetic flux thereby produced in the iron. Total magnetic flux-density. The production of magnetism in a magnetizable substance on its being brought into magnetic flux.

Magnetic Intensity. Magnetic flux-density. The quantity of magnetic flux per-unit-of-area of normal cross-section. Magnetic induction.

Magnetic Leakage. A useless dispersion of magnetic flux of a dynamo or motor by its failure to pass through the armature. Any useless dispersion of magnetic flux by its failure to pass through a magneto-receptive device placed in the magnetic circuit.

Magnetic Needle. A magnetized steel needle or thin straight strip or rod. A straight bar of magnetized steel, supported at or above its centre of gravity, and free to move in a horizontal plane only, in a vertical plane only, or in both.

Magnetic Permeability. Conductivity for magnetic flux. The ratio between the magnetic induction produced in a magnetic substance, and the magnetizing force producing such magnetic induction.

Magnetic Poles. Those parts of a magnetic source from or at which the flux emerges or enters.

Magnetic Reactance. In an alternating-current circuit the reactance of a coil as distinguished from the reactance of a condenser.

Magnetic Reluctance. The resistance offered by a medium to the passage through it of magnetic flux.

Magnetic Saturation. The maximum magnetization which can be imparted to a magnetic substance. The condition of iron, or other magnetic substance, when its intensity of magnetization is so great that it fails to be further magnetized by any magnetizing force, however great.

Magnetic Solenoid. A spiral coil of wire, which acts like a magnet when an electric current is sent through it.

Magnetic Traction. Tractive or supporting power exerted by a magnet. Hauling or carrying effected magnetically.

Magnetic Units. Units based on the force exerted between magnet poles. Units employed in dealing with magnets and magnetic phenomena. The magnetic system of C.G.S. electromagnetic units, as distinguished from the electrostatic system.

Magnetism. That property or condition of matter which accompanies the production of magnetic flux. Magnetic flux or streamings. That branch of science which treats of the nature and properties of magnets and of magnetic flux.

Magnetizing Force. The vector space-rate of descent of magnetic potential. The prime flux-density impressed upon a body, and which may induce magnetism in the same. The force at any point with which a unit magnetic pole would be acted on. The impressed flux-density of a field as distinguished from the total flux-density.

Magneto. A magneto-generator. A small magneto-electric dynamo machine.

Magneto Call=bell. A call-bell operated by a magneto-electric machine.

Magneto=electric Dynamo. A dynamo-electric machine whose field magnets are formed of permanent magnets.

Magnetometer. An apparatus for the measurement of magnetic force. Any apparatus for measuring the elements of the earth's magnetic force.

Magneto=motive Force. The force which produces magnetic flux. The force that moves or tends to move magnetic flux.

Magnet Wire. Insulated wire suitable for winding magnets and usually cotton-covered. (See Index.)

Mains. In a parallel system of distribution the parallel conductors carrying the main current, and to which translating devices are connected. In a system of parallel distribution, the principal conductors which extend from the risers, or service wires, along the corridors or passages along the floor to be lighted.

Make=and=break. The operation of alternately completing and opening a circuit.

Man=hole of Conduit. An opening communicating from the surface of the road bed with an underground conduit, of sufficient size to admit a man.

Man=power. A unit of power equal to the one-tenth of a horse-power, or about 75 watts.

Marconi Rays. Electro-magnetic waves employed in the Marconi system of wireless telegraphy.

Marconi Waves. Electromagnetic waves employed in the Marconi system of wireless telegraphy.

Mariner's Compass. A compass mounted in such a manner as to be serviceable on board ship. A name often applied to an azimuth compass.

Mass. Quantity of matter contained in a body.

Matt. A word employed in electro-plating to designate the appearance presented by an electro-plating of silver in which the deposit is interlaced and closely massed together. A fused mass of impure copper employed as the raw material in electrolytic refinement.

Maximum Demand. The maximum demand may be stated in kilowatts, horse-power, 16-cp equivalents, or any other term specified, but preferably should be stated in terms which leave no opportunity for error, and wherever possible should be stated in kilowatts. Unless specified, it should always mean absolutely the greatest actual maximum demand. If the greatest actual maximum demand is not intended, but it is intended to express the greatest maximum demand for a given day or a given minute, then it should be so stated.

Maximum Instantaneous Demand. The highest load reached as measured by indicating or recording instruments at any moment.

Maximum Simultaneous Demand. A maximum simultaneous demand should be used to express the greatest absolute aggregate sum of certain individual demands, such as:

(a) Customers,
(b) Classes of customers,
(c) Classes of current,

and all rules made to define maximum demand shall apply to simultaneous maximum demand.

Mean Current. The time average of a current strength. In an alternating-current circuit, the time average of a current strength without regard to sign or direction.

Mean Electromotive Force. The average electromotive force. In an alternating-current circuit the time average of the E.M.F. without regard to sign or direction.

Mean Horizontal Intensity of Light. The average intensity of light in a horizontal plane containing the source.

Mean Spherical Candle=power. An average candle-power numerically equal to the total quantity of light emitted by a point source divided by 12,566. The average candle-power of a source taken at all points of the surface of a sphere.

Mechanical Equivalent of Heat. The amount of mechanical energy converted into heat that would be required to raise the temperature of a unit mass of water one degree of the thermometric scale. The quantity of energy mechanically equivalent to one heat unit.

Electrical Dictionary

Meg or Mega. A prefix for one million times.

Megohm. One million ohms.

Mercurial Contact. An electric contact effected through the medium of mercury.

Mercury Break. A form of circuit breaker operated by the removal of a conductor from a mercurial surface.

Mercury Cup. A cup partly filled with mercury employed as a mercurial contact.

Mercury Tube. A sealed glass tube containing mercury arranged to emit fluorescent light when agitated. A resistance formed of a thread of mercury contained in a tube.

Messenger Rope. In cable-work a rope drive for operating a drum or winch at a distance. A rope supporting guide sheaves.

Metallic Arc. An arc formed between metallic electrodes.

Metallic Circuit. A circuit which is metallic throughout, in contradistinction to an earth-return circuit.

Metallic Contact. A contact of a metallic conductor obtained by bringing it into firm connection with another metallic conductor. Contact between metal and metal.

Metallic Cross. A fault due to the actual contact between two or more wires or conductors, so that the current from one line passes to another.

Metallic Resistance. A term sometimes applied to the resistance of wires or conductors, in contradistinction to the resistance of insulating materials.

Meter, Electric. An apparatus for measuring commercially the quantity of electricity that passes in a given time through a consumption circuit.

Meter-motor. A small motor employed in operating an electric meter. A meter comprising a small motor.

Metre. A unit of length equal, approximately, to one ten-millionth part of a quadrant of a meridian of the earth taken through Paris; or, approximately, to 39.37 inches.

Metric Horse-power. A unit of power in which the rate-of-doing-work is equal to 75 kilgramme-metres per second.

Mho. The unit of conductance. Such a conductance as is equal to the reciprocal of one ohm. A unit of electric conductance of the value of 10^{-9} absolute units.

Mica. A refractory, mineral substance employed as an insulator. A double silicate of alumina or magnesia and potash or soda.

Micanite. A variety of insulating material made from and built up of small mica sheets bound together by some insulating cement.

Micro. A prefix for the one-millionth.

Microfarad. One-millionth of a farad.

Micrometer Wire-gauge. A sensitive form of wire gauge, usually constructed with a fine thread screw, having a graduated head for close measurements of wire diameters. (See page 21.)

Microhm. The millionth of an ohm.

Mil. A unit of length used in measuring the diameter of wires equal to the one-thousandth of an inch.

Mil-foot. A resistance standard consisting of a foot of wire, or other conducting material, one mil in diameter. A standard of comparison of resistivity or conductivity of wires. (See page 15.)

Milli-ammeter. A milli-ampere meter.

Milli-ampere. The thousandth of an ampere.

Milli-henry. A thousandth part of a henry.

Milli-volt. The thousandth of a volt.

Minus Charge. A negative charge.

Mirror Galvanometer. A galvanometer whose readings are obtained by the movements of a spot of light reflected from a mirror attached to the needle or its suspension system.

Modulus of Elasticity. The ratio of the simple stress required to produce a small elongation or compression in a rod of unit area of normal cross-section, to the proportionate change of length produced. Young's modulus.

Moisture-proof Insulation. Water-proof insulation. A type of insulation which is not strictly water-proof, but which is capable of being immersed for a short time without suffering serious loss of insulation.

Momentary Peak. The highest average load carried during any fifteen seconds of a specified period.

Monocylic System. A system of alternating-current distribution suitable for electric lighting with the additional capability of operating triphase induction motors. A system for the distribution of alternating currents employing three wires, between two of which an ordinary uniphase pressure is maintained, while between either of them and the third, there is a diphased pressure.

Moonlight Schedule. A schedule of burning hours for lamps which are not lighted when the moon shines.

Morse Recorder. An apparatus for automatically recording the dots and dashes of the Morse telegraphic dispatch, on a fillet of paper drawn under an indenting or marking point on a striking lever connected with the armature of an electro-magnet, as distinguished from a Morse inker.

Morse System of Telegraphy. A system of telegraphy in which makes and breaks, occurring at intervals corresponding to the dots and dashes of the Morse alphabet, are received by an electro-magnetic sounder, or other receiver.

Motor Converter. A combination of an induction motor with a synchronous converter, the secondary of the former feeding the armature of the latter with current at some frequency other than the impressed frequency; i. e., it is a synchronous converter concatenated with an induction motor.

Motor-dynamo. An electrically driven motor, rigidly connected to the armature of a dynamo, and employed for transforming or changing the pressure of a direct-current circuit. The combination, in a continuous current generator of a motor and a dynamo, in separate structures, mechanically connected to form a single machine or structure.

Motor, Electric. A device for transforming electric power into mechanical power.

Motor-generator. A motor coupled to a generator. A motor-dynamo. A transforming device.

Motorman. The man who operates a trolley car.

Motor Starting-rheostat. An adjustable rheostat provided for preventing an abnormal rush of current through a shunt-wound motor, on the starting of the same.

Motor Torque. The rotary effort developed by an electric motor.

Mouth-pieces. Circular openings into air chambers, placed over the diaphragms of telephones, phonographs, gramophones, or graphophones, to permit the ready application of the mouth in speaking, so as to set the diaphragm in vibration.

Multi-conductor Cable. A cable provided with a plurality of conducting circuits.

Multiphase Apparatus. A general term for multiphase alternators, motors, or other receptive apparatus, suitable for use on multiphase circuits.

Multiple-arc Circuit. A term often used for multiple circuit.

Multiple Circuit. A circuit in which a number of separate sources or separate receptive devices, or both, have all their positive poles connected to a single positive lead or conductor, and all their negative poles connected to a single negative lead or conductor.

Multiple-parallel Circuit. A term sometimes employed for a multiple of parallel circuits.

Multiple-series Circuit. A circuit in which a number of separate sources, or receptive devices, or both, are connected in a number of separate groups in series, and these separate groups subsequently connected in multiple.

Multiple Telegraphy. A system for the simultaneous telegraphic transmission over the same wire of more than a single message in the same direction.

Multiple Telephony. The simultaneous transmission over the same wire of a number of separate telephonic despatches, in the same direction.

Multiple Windings. Independent windings symmetrically disposed upon the same armature, insulated from each other, but brought to different segments of the commutator.

Multiplex Telegraphy. A system of telegraphy for the simultaneous transmission in opposite directions of more than two separate messages over a single wire from each end. A term sometimes used for multiple telephony or simultaneous transmission of more than one message in the same direction over a single wire.

Multipolar Armature. An armature suitable for use in a multipolar field.

Multipolar Dynamo. A dynamo provided with a multipolar field.

Mutual Induction. Induction produced on each other by two neighboring circuits through the mutual inter-connection of their magnetic fluxes. Induction produced in neighboring charged conductors by the inter-connection of their electrostatic fluxes.

N.

N. A symbol for the whole number of lines of magnetic flux or induction in any magnetic circuit.

n. A symbol employed for frequency. A contraction for a number.

Needle. A word frequently used for a magnetic needle.

Negative Charge. According to the double-fluid hypothesis, a charge of negative electricity. According to the single-fluid hypothesis, any deficit of an assumed electric fluid. An electric charge of the same character as that produced on silk when rubbed by glass.

Negative Conductor. The conductor connected to the negative terminal of an electric source.

Negative Currents. In telegraphy, a term applied to the currents sent over a line from the negative pole of the battery.

Negative Electricity. One of the phases of electric excitement. The kind of electric charge produced on resin when rubbed with cotton.

Negative Electromotive Force. Such an E.M.F. as is produced at the free pole of a battery or other source whose positive pole is grounded.

Negative Electrode. The electrode connected with the negative terminal of a source.

Negative Feeders. The feeders connecting the negative mains with the negative poles of the generators.

Negative Potential. A potential such as determines a tendency of electricity to flow towards it from the earth or from any point of positive potential. Generally, the lower potential or lower level. That property of a point in space by virtue of which electric work is done by the movement of a small positive charge to that point from an infinite distance.

Negative Rays. The molecular streams given off at the negative electrode or cathode of an induction tube, on the passage of electric discharges through the tube.

Negative Terminal. The terminal of a voltaic cell connected with the positive plate or element. The terminal of a source connected with the negative pole. The terminal of a translating device connected with the negative pole of the source.

Nernst Lamp. A form of incandescent light in which a substance called the glower is the source of light. When cold the glower is a non-conductor and it must be artificially heated to bring it into action.

Neutral Conductor. The neutral wire in a three-wire system.

Neutral Feeder. In a three-wire system, a feeder connected with the neutral bus-bar.

Neutral-line of Dynamo Armature. A line passing through the armature, symmetrically disposed as regards its entering and emerging flux. A line of zero polarity.

Neutral Point. A term sometimes employed in electro-therapeutics for indifferent point.

Neutral Wire. In a three-wire system of electric distribution the wire connected to the neutral dynamo-terminal. The balance wire of a three-wire system.

Nigger. A term sometimes employed for a fault in any electric apparatus or system.

Non-arcing Fuse. A fuse wire formed of non-arcing metal, which, therefore, blows without the formation of a voltaic arc.

Non-conductor. Any substance whose conductivity is low, or whose electric resistance is great.

Non-ferric. Devoid of iron.

Non-inductive Resistance. A resistance devoid of self-induction.

Non-peak Rate. See "Off-peak Rate."

Non-reactive Circuit. A circuit which possesses neither inductance nor capacity, and, therefore, has ohmic resistance only.

Normal Current. The current strength at which a system or apparatus is designed to be operated.

North Magnetic Pole. That pole of a magnetic needle which points approximately to the earth's geographical north.

O.

O. An abbreviation for ohm, the practical unit of resistance.

O.K. A telegraphic signal of acquiescence meaning "all right" and said to be a perversion of the initial letters of the phrase "all correct."

ω. A symbol sometimes employed for angular velocity.

Oersted. The name used for the C.G.S. unit of magnetic reluctance. The reluctance offered to the passage of magnetic flux by a cubic centimetre of air when measured between parallel faces.

Off-peak Rate. A rate conditioned on the non-use of service during specified hours of central-station peak-load.

Ohm. The practical unit of electric resistance. Such a resistance as would limit the flow of electricity under an electromotive force of one volt, to a current of one ampere, or one-coulomb-per-second. (See International Ohm.)

Ohmic. Of or pertaining to the ohm. Having the nature of an electric resistance.

Ohmic Drop. The drop in pressure due to the ohmic resistance.

Ohmic Resistance. The true resistance of a conductor due to its dimensions and conductivity, as distinguished from the spurious resistance produced by counter-electromotive force. A resistance such as would be measurable in ohms by the usual methods of continuous-current measurement.

Ohm's Law. See Law of Ohm.

Oil Insulator. A fluid insulator containing oil.

Oil Transformer. A transformer immersed in oil in order to ensure and maintain high insulation. An oil-insulated transformer.

Omnibus Bars. Heavy bars of copper connected directly to the poles of a dynamo in a central station, and, therefore, receiving their entire current. Main conducts common to two or more dynamos in an electrical generating plant.

Electrical Dictionary

Open Circuit. A broken circuit, or a circuit whose conducting continuity is broken.

Open=circuit Transformer. A transformer whose magnetic circuit is partly completed through air. An aero-ferric-circuit transformer.

Open=coil Armature. An armature, some of whose coils are on open-circuit during a portion of the rotation of the armature.

Open Wiring. Wiring that has been purposely left exposed to view. Wiring supported on cleats or insulators as distinguished from channelled, panelled, or covered wiring.

Opening a Circuit. Breaking a circuit.

Operating Time=factor. The ratio of the number of hours of operation to the number of hours in the interval considered. This can best be fixed by an example: There are 8760 hours in the year. If a given shop operates ten hours a day, for 300 days in a year, it may be said to have an operating factor of 34.11 per cent.

Operating Time Load=factor. The load-factor considered only during the time of operation. This can also best be defined by example, and would be used to express the load-factor for the running time of a shop. That is, if a shop operates ten hours a day and 300 days in a year, the divisor would be 3000 hours, or such other number of hours, as represented the time of running instead of the usual divisor of 8760 hours in the year.

Ordinate. In graphics, a distance taken on a line called the axis of ordinates.

Oscillating Current. An oscillatory current. A periodically alternating current and of diminishing amplitude.

Oscillator, Electric. A device for producing electric currents of a constant period, independently of variations in its driving force.

Oscillatory Current. A current which oscillates or performs periodic vibrations usually of diminishing amplitude.

Oscillograph. An instrument for recording rapid variations of an electrical current or pressure, usually consisting of a combination of a suitable form of galvanometer with a photographic recording apparatus. A cathode-ray tube in which the cathode rays are deflected by the application of a magnetic field.

Osmose, Electric. The unequal difference of diffusion between two liquids placed on opposite sides of a diaphragm, produced by the passage of an electric current through the diaphragm.

Outboard Bearing. A journal bearing projecting beyond the base frame of a machine for giving adequate support to a long or heavy shaft. A separate journal bearing supported outside the frame of a machine.

Outlet. A place where branch wires come out in a wall or ceiling for connection to a switch, lamp or other device. In a system of incandescent-lamp distribution the place in the building where the fixtures or lamps are attached.

Output of Dynamo=electric Machine. The electric power of the current developed by a dynamo-electric generator or transformer, at its delivery terminals expressed in volt-amperes, watts, or kilowatts. The available mechanical power developed by a motor, or the power delivered at its pulley or shaft.

Overhead Conductor. An aerial conductor.

Overload Switch. A switch designed to automatically open a circuit upon the occurrence of an overload.

Overtone Currents. Electric currents of harmonic frequencies accompanying a fundamental periodic current.

P.

P. A symbol for power.

ϕ A symbol for quantity of magnetic flux.

P.D. or **p.d.** A contraction frequently employed for potential difference.

Page Effect. Faint sounds produced when a piece of iron is rapidly magnetized and demagnetized.

Paper Cable. A paper-insulated cable. A cable in which paper is the solid insulator employed. (See Index.)

Paper Insulation. Insulation obtained by paper.

Paraffine. A solid hydro-carbon possessing high insulating powers.

Parallel Circuit. A term sometimes used for multiple circuit.

Parallel=working of Dynamo=electric Machines. The working of two or more dynamos in parallel.

Paramagnet. A magnet produced by iron or other magnetic substance. A ferromagnet.

Paramagnetic. Possessing the properties ordinarily recognized as magnetic. Possessing the power of concentrating lines of magnetic force. Ferromagnetic.

Party Line. A telephone circuit which serves for more than one customer.

Paying=out. The operation of passing submarine cable out of the ship while laying it.

Peak. The highest average load carried during one minute of any specified period.

Peak-load. The highest average load carried during one hour of any specified period.

Note: In the case of momentary peak load=factor, peak=loads, the terms may be preceded by the qualifying terms "hourly," "daily," "monthly," "yearly," etc.

Peltier Effect. The heating effect produced by the passage of an electric current across a thermo-electric junction, or surface of contact between two different metals, as distinguished from a Joulean effect or heat due to resistance merely.

Pendant Cord. A flexible conductor provided for conveying the current to a pendant lamp or rush.

Pendant Socket. An attachment provided with a chain or chains for turning on or off a lamp not readily accessible.

Pendulum, Electric. A pendulum so arranged that its to-and-fro motions send electric impulses over a line, either by making or breaking contacts. An electric tuning fork whose to-and-fro movements are maintained by electric impulses.

Percentage Conductivity of Wire. The conductivity of a wire in terms of the conductivity of pure copper. The conductivity of a particular copper wire compared with the conductivity of a standard wire of the same dimensions. The conductivity of a wire referred to Matthiessen's standard of conductivity for copper.

Period. The interval of time between two successive passages of a vibration through a given point of its path taken in the same direction. The time occupied in performing a complete cycle.

Periodic Alternating Electromotive Force. An electromotive force whose direction periodically varies.

Periodic Current. A current whose strength and direction periodically vary. A simple harmonic or sinusoidal current. A periodically alternating current.

Periodicity. The number of periods executed per second by a periodically alternating quantity. The number of cycles executed in unit time by an alternating current. The frequency of an alternating current.

Peripheral Speed. The speed of a point on the circumference of a rotating cylinder or wheel.

Permanent Magnet. A name sometimes given to a magnet composed of hardened steel, whose magnetic retentivity is high.

Permeability Bridge. A device for measuring the magnetic permeability of a medium, operating on the principle of a Wheatstone bridge.

Permittance. Electrostatic capacity. The capability of a condenser or dielectric to hold a charge.

Personal Equation. A constant observational error peculiar to an observer, and depending upon his psychological condition.

Petticoat Insulator. An insulator provided with a petticoat, or deep internal groove, around its lower extremity, or stalk. A line-wire vertical insulator provided with an insulating inverted cup having a form resembling a petticoat. An ordinary telegraph or telephone single-cup insulator.

Phantom Circuit. Any of the additional circuits established on a telegraphic line by means of any variety of multiplex telegraphy. An imaginary circuit virtually created by multiplexing a telegraph circuit.

Phase. The fractional part of a period, which has elapsed since a vibrating body last passed through the extreme point of its path in the positive direction.

Phase Angle. The angle of phase, in a simple-harmonic motion, or the angular distance through which the corresponding circularly moving point has passed from the point of last maximum positive elongation.

Phase Indicator. A device for indicating when the pressure of an alternator is in phase and synchronism with the pressure of the circuit with which it is to be connected. A term sometimes employed for a synchronizer.

Phone. A contraction frequently employed for telephone. A message sent by telephone.

Phone. To send a message by telephone.

Photometer. An apparatus for measuring the intensity of the light emitted by any luminous source.

Pile. A word frequently used for voltaic or thermo-electric pile, though more frequently for the former. A voltaic or thermo-electric battery.

Pilot Brush. A small accessory brush placed on the commutator cylinder for the purpose of determining the variations in the electromotive force produced in various segments.

Pilot Lamp. A lamp connected across the terminals of a dynamo to show roughly the pressure which it is producing. A lamp placed in a central station, generally on the dynamo itself, to indicate the difference of potential at the dynamo terminals by means of the intensity of the emitted light.

Pilot Wires. The wires leading directly to the generating station from different parts of the mains, in order to determine the difference of potential at such parts. Wires provided for connection to a pilot lamp, or other device for indicating the maintenance of normal pressure.

Pins. Wooden pegs for supporting pole line insulators.

Pitch. The frequency of an electrically produced tone. The distance between successive corresponding conductors on a dynamo armature. In an armature winding divided into coils or segments, the number of coils through which advance must be made in making end connections between the coils.

Pitch Line. A circle drawn around the external surface of an armature through the middle of the length of the inductors placed thereon.

Pitch of Windings. In alternators, usually the distance measured along the pitch line between the centers of a pair of successive poles of opposite sign; or, in some alternators, half this distance. In a continuous-current armature, the pitch.

Pith-ball Electroscope. An electroscope whose indications are obtained by the attractions or repulsions of pith balls.

Plane Vector. A quantity which possesses not only magnitude but also direction in a single plane.

Planimeter. An instrument for automatically integrating the areas of plane curves, around the contour of which a fiducial point on the instrument is carried.

Platinum. A heavy, refractory and not readily oxydizable metal of a tin-white color.

Plow Steel. See Index.

Plug Resistances. A number of separate resistances that can be introduced into a circuit by unplugging. The resistances of the ordinary resistance box.

Plug Switch. A switch operated by the insertion of a metallic plug between two insulated metallic segments connected to a circuit, and separated by air-spaces for the reception of the plug key.

Plumbago. An allotropic modification of carbon.

Plunger Switch. A switch, the operating lever cylinder of which passes through a bushing in a switchboard, so as to make and break contacts at the back of the switchboard.

Polarity. The possession of poles, or of opposite properties, at opposite ends. The condition of electric or magnetic differentiation between properties of electric or magnetic flux depending on and inherent in the direction of such flux.

Polarization of Dielectric. A molecular strain produced in the dielectric of a Leyden jar, or other condenser, by the attraction of the electric charges on its opposite faces, or by electrostatic stress. A term sometimes employed for electric displacement.

Pole Changer. A switch for reversing the direction of a current. A reverser. A generator of alternating currents at a telephone exchange, consisting of an electro-magnetically driven pendulum which periodically reverses a call battery.

Pole Guys. A guy employed for stiffening a pole.

Pole Steps. Steps permanently fastened to a wooden or iron pole to facilitate climbing. (See page 81.)

Polyphase. Possessing more than a single phase.

Polyphase Alternator. An alternator capable of supplying polyphase currents.

Polyphase Armature. An armature so wound as either to produce polyphase currents, or to be operated by such currents.

Polyphase Circuits. The circuits employed in polyphase-current distribution.

Polyphase Currents. Currents differing in phase from one another by a definite amount, and suitable for the operation of polyphase motors or similar apparatus.

Polyphase Generator. A generator which produces currents differing symmetrically in phase.

Polyphase Motor. A motor operated by means of polyphase currents.

Polyphase Transformer. A transformer suitable for use in connection with polyphase circuits.

Polyphase Transmission. Transmission of power by means of polyphase currents.

Polyphaser. A term sometimes employed for a polyphase alternator, or generator. A multiphaser.

Pony Insulators. A name given to a particular type of glass telegraph insulator.

Porcelain. A variety of insulating substance, made from kaolin.

Portable Conductors. Flexible cords containing insulated wires suitable for use with portable lamps, motors, or other devices.

Positive Charge. According to the double-fluid hypothesis, a charge of positive electricity. According to the single-fluid hypothesis, any excess of an assumed electric fluid. A charge of electricity having a positive potential.

Positive Currents. A term employed in telegraphy for currents sent over a line from the positive pole of a battery.

Positive Electricity. One of the phases of electric excitement. That kind of electric charge produced on cotton when rubbed against resin.

Electrical Dictionary

Positive Lead. In a system of parallel distribution, a lead connected with the positive generator-terminal, or with the positive bus-bars.

Positive Pole. That pole of an electric source out of which the current is assumed to flow.

Positive Wire. The wire connected with the positive pole of a source.

Potential, Electric. The power of doing electric work. Electric level.

Potential Energy. Stored energy. Potency or capability of doing work. Energy possessing the power or potency of doing work but not actually performing such work.

Potential Indicator. An apparatus for indicating potential difference.

Potential of Conductors. The relation existing between the quantity of electricity in a conductor and its capacity. That property of a conductor whereby electric work is done when an electric charge is moved towards it.

Power. Rate-of-doing-work, expressible in watts, joules-per-second, foot pounds-per-hour, etc. Activity.

Power Circuits. Circuits employed for the electric transmission of power.

Power Factor. The ratio of the true watts to the apparent volt-amperes in an alternating-current conductor, circuit, or device. It equals the cosine of the angle of lag of the alternating current.

Power-factor Indicator. A device to indicate the power-factor of an electric current.

Power-house. A house provided with the plant necessary for the production of the electric power required in a system of electric distribution.

Practical Units. Definitely related multiples or sub-multiples of the absolute or centimetre-gramme-second units.

Prepayment Meter. A device whereby a certain electric service is given by means of an electric penny-in-the-slot apparatus.

Pressure Equalizer. An automatic device employed in connection with a storage battery to maintain a uniform pressure at its terminals under different loads. A regulating device employed in a system of electric distribution for maintaining the pressure uniform.

Pressure Indicator. Any device for indicating the electric pressure in a circuit.

Pressure Wires. Small insulated copper conductors, employed in a system of underground street mains, extending from points of junction between the feeders and the mains to the central station, to indicate in the central station the pressure supplied to the mains.

Primary. That winding of an induction motor or of a transformer which directly receives power. The term is to be preceded, in the case of transformers, by the words "high voltage" or "low voltage," in the case of induction motors by "rotating" or "stationary."

Primary Battery. The combination of a number of separate primary cells to form a single electric source.

Primary Cell. A term sometimes employed for a voltaic cell.

Primary Coil of Transformer. That coil of an induction coil or transformer on which the primary electromotive force is impressed. The coil which receives energy prior to transformation.

Primary Currents. Currents flowing in a primary circuit, as distinguished from currents flowing in a secondary circuit.

Primary Electromotive Force. The electromotive force applied to the primary coil of a transformer.

Primary Winding is that winding of an induction motor or of a transformer which receives power from an external source.

Prime Magneto-motive Force. The magneto-motive force due to the magnetizing current in a ferric circuit.

Prony Brake. A mechanical device for measuring the power of a driving shaft by the application of a brake to the periphery of a wheel firmly keyed on the shaft.

Proportionate Arms. The two resistances or arms of an electric bridge, whose relative or proportionate resistances only are required to be known, in order to determine in connection with a known resistance, the value of an unknown resistance placed in the remaining arm of the bridge.

Pull-off. An insulator employed on curves to hold the trolley wire in proper position. A steel wire attached to a trolley wire through an insulator, and employed to pull the trolley wire into position over a curve in the track.

Pulsating Current. A current equivalent to the superposition of an alternating current upon a continuous current.

Pulse, Electric. An electric oscillation. A momentary flow of electricity through a conductor which gradually varies from zero value to the maximum, and then to zero value again, like a pulse or vibration in an elastic medium.

Pumping of Alternating-current Dynamo. A pulsation in the motion of a synchronously running alternating-current generator or motor, due to imperfect synchronism.

Push Button. A device for closing an electric circuit by the movement of a button.

Push Contact. A name sometimes applied to a push button.

Pyrometer, Electric. A device for determining the temperature of a body by the measurement of the electric resistance of a platinum wire exposed to the heat to be measured.

Q.

Q or q. A symbol for electric quantity.

Quadrant Electrometer. An electrometer in which an electrostatic charge is measured by the attractive and repulsive force exerted by four plates or quadrants on a light needle of aluminum suspended between them.

Quadrature. A term applied to express the fact that one simple-harmonic quantity lags 90° behind another.

Quadruplex. Of or pertaining to quadruplex telegraphy.

Quadruplex Telegraphy. A system for the simultaneous transmission of four messages over a single wire, two in one direction and two in the opposite direction.

Quadruplex Telephony. The simultaneous transmission of four telephonic messages, two in one direction and the remaining two in the opposite direction.

Quantity, Electric. The amount of electricity present in any current or charge.

Quantity Increment Rate. See "Block Rate."

Quarter Phase. A term implying the supplying of power through two circuits. The vector angle of this voltage is 90 degrees. This term is recommended instead of the term "two-phase."

Quarter-phase System. A two-phase system of alternating-current distribution employing two currents dephased by a quarter period.

Quartze Fibre. (See Fibre, Quartz.)

Quick-break Switch. A switch by means of which a circuit may be rapidly broken.

R.

R. A contraction for ohmic resistance.

r. A symbol for radius.

R.M.S. A term sometimes used for the square root of the mean square of the current. The effective current.

R.P.M. An abbreviation for revolutions per minute.

Radian. A unit angle. An angle whose circular arc is equal in length to its radius; or, approximately 57° 17′ 45″.

Radian-per Second. A unit of angular velocity of a rotating body.

Electrical Dictionary

Radiation, Electric. The transference of electric energy by means of electro-magnetic waves set up in the surrounding ether. That property of a rapidly oscillating or alternating-current circuit by virtue of which energy is expended by the circuit in the form of electromagnetic waves.

Radius of Gyration. In a rotating body, a radial distance from the center of rotation at which, if the entire mass of the body were collected, its moment of inertia would remain the same.

Rail-bond, Electric. Any device whereby the ends of contiguous rails are placed in good electrical contact with one another, so that the resistance of the rails, employed as a portion of the return circuit, may be as small as possible.

Railway Return Circuit. A term frequently employed for the ground return of a trolley system. The return circuit, generally a grounded circuit, employed in trolley systems.

Rate-of-doing-work. Activity. Power.

Ratio of Transformation. The ratio between the electromotive force produced at the secondary terminals of an induction coil or transformer, and the electromotive force impressed on the primary terminals.

Reactance. The inductance of a coil or circuit multiplied by the angular velocity of the sinusoidal current passing through it. A quantity whose square added to the square of the resistance gives the square of the impedance, in a simple-harmonic current circuit.

Reactance Coil. A coil for producing difference of phase or for eliminating current. A magnetizing coil surrounded by a conducting covering or sheathing which opposes the passage of rapidly alternating currents less when directly over the magnetizing coil than when a short distance from it. A choking coil or reactor.

Reactance Factor. The ratio of the reactance of a coil, or circuit, to its ohmic resistance.

Reactive Circuit. A circuit containing either inductance or capacity alone, or both inductance and capacity.

Reactive Drop. The drop in a circuit or conductor due to its reactance, as distinguished from the drop due to its ohmic resistance.

Reactive Electromotive Force. In an alternating-current circuit, that component of the electromotive force that is in quadrature with the current and is employed in balancing the C.E.M.F. of inductance.

Reactive Factor. The ratio of the wattless volt-amperes to the total volt-amperes.

Receiver. A name given to a receiving instrument of a gramophone, graphophone, telephone or telegraph instrument.

Recording Ammeter, Recording Voltmeter, Recording Wattmeter. Instruments which record upon a time-chart a continuous record of the value of quantities they measure.

Recording Drum. A cylindrical drum covered by a sheet or strip of paper on which a chronographic or other record is made.

Recording Wattmeter. A recording form of wattmeter.

Rectified. Commuted, or caused to take one and the same direction.

Rectilinear Current. A current flowing through a straight or rectilinear portion of a circuit.

Reed Interrupter. A form of automatic make-and-break contact, operated by the vibrations of a reed.

Re-entrant Armature-windings. Armature windings, which, when followed in either direction, lead back to the starting point.

Reflecting Galvanometer. A term sometimes applied to a mirror galvanometer.

Regenerative Arc Lamp. A flaming enclosing arc lamp in which the products of combustion are circulating and brought rapidly in contact with the arc. The objects accomplished thereby are:

1.—To conserve the heat;
2.—To condense and deposit the solid products of combustion where they will not obstruct the light, and
3.—To exclude the oxygen and utilize rapidly the chemicals in the circulating gases.

Regulation. The regulation of a machine or apparatus in regard to some characteristic quantity, such as current or terminal voltage, is the ratio of the deviation of that quantity from its normal value at rated-load to the normal rated-load value. Sometimes called inherent regulation.

Relative Inductivity. The ratio of the inductivity of a medium to the inductivity of vacuum.

Relay. In telegraphy, an electro-magnet provided with contact points placed on a delicately supported armature, the movements of which open or close a local receiver circuit.

Relay Magnet. A term sometimes given to a relay. The permanent magnet of a polarized relay. The electro-magnet of a relay.

Reluctance. A term applied to magnetic resistance. In a magnetic circuit the ratio of the M.M.F. to the total magnetic flux.

Reluctivity. The specific magnetic resistance of a medium.

Repeating Relay. A relay employed in a repeater. The relay in a telegraph circuit which repeats the signals into another circuit.

Repulsion Motor. An electric motor deriving its power from the repulsion between electric charges. An alternating-current motor deriving its power from the repulsion between electric currents. An alternating-current motor in which the armature is provided with temporarily short-circuited windings by means of a commutator and brushes.

Residual Charge. The charge remaining in a Leyden jar after it has been disruptively discharged.

Residual Magnetism. The magnetism remaining in a core of an electromagnet on the opening of the magnetizing circuit. The small amount of magnetism retained by soft iron when removed from any magnetic flux.

Resin. A general term applied to a variety of dried juices of vegetable origin.

Resinous Electricity. A term formerly employed in place of negative electricity.

Resistance. A word sometimes used for electric resistance. Obstruction to flow.

Resistance Box. A term employed for a box containing graduated resistance coils.

Resistance Coil. A coil of wire, strip, or conductor, possessing electric resistance. A coil of wire, of known electric resistance, employed for measuring an unknown electric resistance.

Resistance, Electric. The ratio between the electromotive force of a circuit and the current that passes therein. The reciprocal of electric conductance. (See page 79.)

Resistivity. The specific resistance of a substance referred to the resistance of a cube of unit volume. Specific resistance, or the inverse of specific conductivity.

Resonance. In a simple-harmonic current, circuit or branch, containing both inductance and capacity, the neutralization or annulment of inductance-reactance by capacity-reactance, whereby the impedance of the circuit or branch is reduced to the ohmic resistance. In an alternating-current circuit, or branch, containing localized inductance and capacity, the re-enforcement of condenser pressure, inductance pressure, or current strength, due to the mutual neutralization or opposition of inductance and capacity-reactances. In an alternating-current circuit, or branch, the attunement of a circuit, containing a condenser to the same natural undamped frequency of oscillation as the frequency of impressed E.M.F. whereby the circuit responds to this frequency more than to any other. In an alternating-current circuit, or branch, the annulment of inductance-reactance by capacity-reactance, whereby the impedance of the circuit or branch is not only reduced to its ohmic resistance, but its current is in phase with its impressed E.M.F.

Resonant Capacity. The capacity of a resonant circuit, or such a capacity as will render an alternating-current circuit resonant.

Resonant Circuit. A circuit whose dimensions are such as to bring it into resonance with a neighboring circuit. A circuit containing distributed inductance and capacity, in which resonant effects are thereby produced.

Resonant Inductance. The inductance of a resonant circuit, or the inductance which will render it resonant.

Resultant Magnetic Field. A single magnetic field produced by two or more co-existing magnetic fields.

Return Circuit. That part of a circuit by which an electric current returns to the source.

Return Current. In telegraphy the electro-static discharge from a cable or underground wire.

Reverse Currents. A name sometimes applied to alternating currents. A name sometimes applied to double current.

Reverse-current Relay. A relay used on a direct-current circuit, which operates when the current flows in the direction opposite to the normal direction.

Reverse-power Relay. A relay which operates when the power in the circuit flows in the direction opposite to the normal direction.

Reversing Switch. A switch employed in reversing a circuit or current.

Rheostat. An adjustable resistance.

Ribbon Conductor. A flat, ribbon-shaped conductor.

Right-handed Rotation. A direction of rotation which is the same as that of the hands of a watch, when one looks directly at the face of the watch. Negative rotation.

Ring Armature. An armature provided with a ring-shaped core.

Ring Core. A ring-armature core.

Ring-off. A term employed for a signal sent by a telephone correspondent when the conversation is finished.

Ring Windings. Windings suitable for use in a ring-wound armature.

Ringing Key. In a telephone switch-board, a key employed to ring up a subscriber.

Risers. Supply wires which lead the current from the service wires to the different floors of a building. The supply wires which rise to the various floors, as distinguished from floor mains, submarine, or branches, which run along each floor.

Rocker Arm. An arm on which the brushes of a dynamo or motor are mounted for the purpose of shifting their position on the commutator.

Rodding a Conduit. The process of introducing a drawing-in wire through the ducts of an underground conduit by pushing a number of short sections of jointed rods through such ducts.

Roentgen Effects. The peculiar effects produced by Roentgen or X-rays.

Roentgen Rays. A peculiar radiation emitted in the neighborhood of that portion of a high vacuum tube on which the cathode rays fall.

Roentgen Tube. Any high-vacuum tube capable of producing Roentgen rays.

Rosette. An ornamental plate provided with service wires and placed in a wall or ceiling for the ready attachment of an electric lamp or electrolier. A word sometimes used in place of ceiling rose.

Rotary, Converter. A secondary generator for transforming alternating into continuous currents or vice-versa, consisting of an alternating-current machine whose armature winding is connected with a commutator; or of a continuous-current machine, whose armature is tapped at symmetrical points and connected to collector rings; so that, when the armature runs it is an alternator on one side and a direct current machine on the other. A rotary transformer.

Rotary Current. A name applied to any system of polyphase currents which are capable of producing a rotary field. A rotating-current distribution.

Rotary Electric Field. A rotary electro-static field.

Rotary-field Motor. A rotary-field induction-motor.

Rotary-magnetic Field. A field produced by a rotary current. A magnetic field in which a set of magnet poles is produced, whose successive positions are such that a rotation of the field is effected.

Rotary Phase Converter. A machine which converts from an alternating-current system of one or more phases to an alternating-current system of a different number of phases, but of the same frequency.

Rotary Transformer. A term generally employed for the combination of a motor and generator in one machine having a single armature-winding traversed both by alternating and continuous currents. A secondary generator for transforming from alternating to continuous currents or vice-versa. A rotary converter.

Rotor. The rotating member, whether primary or secondary, of any alternating-current machine.

Rubber Tape. A form of adhesive, insulating tape made of rubber.

Ruhmkorff Coil. An early form of induction coil or step-up transformer. An induction coil having an iron-wire core, and a fine wire secondary coil of many turns for the production of powerful induced E.M.F.'s usually excited from a battery or continuous current source through a suitable current breaker.

S.

S. A contraction for second.

S.P. Cut-out. A contraction for single-pole cut-out.

S.W.G. A contraction for Stubb's wire gauge.

Saddle Bracket. A bracket holding an insulator and fastened to the top of a telegraph or telephone pole.

Safety Cut-out. A safety fuse.

Safety Fuse. A wire, bar, plate or strip of readily fusible metal, capable of conducting, without fusing, the current ordinarily employed on the circuit, but which fuses and thus automatically breaks the circuit on the passage of an abnormally strong current.

Safety Lamp, Electric. An incandescent lamp, provided with thoroughly insulated leads, employed in mines or other similar places where the explosive effects of readily ignited substances are to be feared. A portable electric incandescent lamp and battery for use in mines where explosive gases may be found.

Sag of Conductor or Line Wire. The dip of an aerial wire or conductor, between two adjacent supports, due to its weight.

Saturating Flux. The flux required to produce magnetic saturation in any circuit.

Saturation Factor. This is the ratio of a small percentage increase in field excitation to the corresponding percentage increase in the voltage thereby produced.

Scratch Brush. A brush made of wires, or stiff bristles, employed for cleansing the surfaces of metallic objects before subjecting them to the electro-plating process.

Screen, Electric. A closed conductor placed over a body in order to protect or screen it from the effects of external electrostatic field.

Secohmmeter. An apparatus for measuring the self-inductance, the mutual inductance, or the capacity of conductors.

Secondary Ampere-turns. Ampere-turns in the secondary of a transformer or induction coil.

Secondary. That portion of an induction motor or of a transformer which receives power by induction. The term is to be preceded by the same words as in the case of "primary."

Secondary Battery. A word frequently used for storage battery.

Secondary Coil of Transformer. The coil of a transformer into which energy is transferred from the primary line and primary coil. The secondary winding of a transformer or induction coil. The coil in the external circuit of which there is no directly impressed E.M.F.

Secondary Currents. The currents produced in the secondary of a transformer. The currents produced by secondary batteries. Currents in any secondary circuit.

Secondary Electromotive Forces. A name sometimes given to the electromotive forces produced by a secondary cell or battery.

Secondary Resistance. The resistance of a secondary coil or circuit.

Secondary Winding is that winding of an induction motor or of a transformer which receives power from the primary by induction.

Note: The terms "High-tension winding" and Low-tension winding" are suitable for distinguishing between the windings of a transformer where the relations of the apparatus to the source of power are not involved.

Section Circuit-breaker. A magnetic circuit-breaker controlling a trolley-wire section.

Section Insulator. An insulator in a trolley-wire system, which electrically disconnects one trolley section from another.

Section Switch. In a system of railway or power-distribution, a switch controlling and supplying a section.

See-sawing. A term employed to characterize the condition of two parallel-connected alternators when they do not synchronize properly.

Self-excitation. An excitation of the field magnets of a generator obtained by leading a portion or all of its own current through its field coils, as distinguished from separate excitation.

Self-induced Current. A current induced in a circuit on the opening or closing of the circuit, by changes in its own strength.

Self-induction. Induction produced in a circuit by the induction of the current on itself at the moment of starting or stopping the current therein.

Self-induction Coil. A coil of wire possessing self-induction. A choking coil.

Sensitive Discharge. A thin, thread-like discharge that occurs between the terminals of a high-frequency induction coil.

Sensitive Tube. A coherer.

Separate Excitation. The excitation of the field magnets produced by a source external to the machine.

Series Circuit. A circuit in which the separate sources or separate electro-receptive devices, or both, are so placed that the current produced in it or passed through it passes successively through the entire circuit from the first to the last.

Series Distribution. A distribution of electric energy in which the receptive devices are placed one after another in succession upon a single conductor, extending throughout the entire circuit from pole to pole.

Series Dynamo. A dynamo having series winding.

Series Motor. A motor suitable for use in a series circuit. A series-wound motor.

Series-multiple Car-controller. A controller provided for starting and stopping a double motor car, for varying its speed, or the torque of its motors, by connecting the motors either in series or in parallel with or without resistances.

Series-multiple Circuit. A compound circuit in which a number of separate sources, or separate electro-receptive devices, or both, are connected in a number of separate groups in multiple arc, and these separate groups subsequently connected in series.

Series-multiple Connection. Such a connection of a number of separate electro-receptive devices that the devices are placed in multiple groups or circuits and these separate groups afterwards connected with one another in series.

Series-parallel Controller. A series-multiple car-controller.

Series Winding A winding of a dynamo electric machine in which a single set of magnetizing coils are placed on the field-magnet cores and connected in series with the armature and the external circuit.

Series-wound Field. The field of a dynamo in which the armature current passes through the magnetizing coil.

Service Conductors. Service wires.

Service Wires. The wires which lead into a building and which are connected to the supply mains or supply circuits. The wires through which service is given to a consumer. Delivery wires.

Sextipolar Field. A field produced by six magnet poles.

Sheathing Wires. The metallic wires which form the armor of a submarine cable.

Shed of Insulator. A petticoat or inverted cone of a telegraph insulator.

Shell Transformer. A transformer whose primary and secondary coils are laid on each other, and the iron core is then wound through and over them, so as to completely enclose them. A form of iron-clad transformer.

Shellac. A resinous substance obtained from the roots and branches of certain tropical plants, which possesses high insulating powers, and high specific inductive capacity.

Short Circuit. A shunt or by-path of negligible or comparatively small resistance, placed around any part of an electric circuit through which so much of the current passes as to virtually cut out the parts of the circuit to which it acts as a shunt. An accidental direct connection between the mains or main terminals of a dynamo or system producing a heavy overload of current. To accidentally produce a short circuit.

Short-circuited Conductor. A conductor which has a short-circuit established past it.

Short-circuiting Plug. A plug which when inserted in its receptacle short circuits the device connected therewith.

Short-shunt Compound-winding. A compound winding of a dynamo-electric machine in which the shunt coil is connected directly, or through resistance, with the armature brushes, as distinguished from a long-shunt compound-winding.

Shunt. An additional, or by-path established for the passage of an electric current or discharge.

Shunt-circuit. A derived circuit. A branch or additional circuit, provided in any part of a circuit, through which the current branches or divides, part flowing in the original circuit and part through the new branch or shunt. A circuit for diverting or shunting a portion of the current.

Shunt Dynamo. A shunt-wound dynamo-electric machine.

Shunt for Ammeter. A shunt coil connection in multiple with the coils of an ammeter for the purpose of changing the value of the readings. A reducteur.

Shunt Ratio. The ratio existing between a shunt and the circuit it shunts. The ratio existing between the total current strength and the current strength in the branch to which the shunt is applied.

Shunt Turns of Dynamo. The ampere turns in the shunt circuit of a shunt-wound or compound-wound dynamo.

Shunt Winding. A term sometimes employed for the shunt field coils on a shunt-wound dynamo or motor.

Shunt-wound Dynamo Electric Machine. A dynamo electric machine whose field-magnet coils are placed in shunt with the armature circuit, so that only a portion of the current generated passes through the field magnet coils, but all the difference of potential of the armature acts at the terminals of the field circuit.

Shuttle Armature. A variety of drum armature in which a single coil of wire is wound in an H-shaped groove formed in a bobbin-shaped core. The old form of Siemens' armature.

Side-pole Trolley-line Construction. A method for the suspension of aerial trolley lines in which the trolley and feed wires are suspended from poles placed on one side of the street or road. (See page 62.)

Siemens-Martin Steel. See Index.

Signal Arm. A semaphore arm.

Silico-magnetic Core Steel. (See page 52.)

Silver Voltameter. A voltameter in which the quantity of electricity passing is determined by the weight of silver deposited.

Simple Alternating-currents. Sinusoidal-alternating currents. Simple-harmonic currents.

Simple-harmonic Electromotive Forces. Electromotive forces which vary in such a manner as to produce simple-harmonic currents; or, electromotive forces whose variations can be correctly represented by a simple-harmonic curve.

Simple-periodic Motion. Simple-harmonic motion.

Simultaneous Demand. The sum of the demands of a number of services occurring at the same time.

Simultaneous Demand Factor. The ratio of the simultaneous demand divided by the connected load.

Simultaneous Maximum Demand. See "Maximum Simultaneous Demand."

Sine Law. A law of magnitude defined by the sines of angles. A magnitude which follows the sines of successive angles.

Single-Phase. Uniphase. Monophase. Pertaining to ordinary alternating currents in a simple alternating-current system as distinguished from multiphase currents.

Single-phase Alternating Current. A uniphase alternating current.

Single-phase Alternator. An alternator capable of producing simple or single-phase currents.

Single-phase Induction Motor. An induction motor intended to be operated on a single-phase alternating-current circuit.

Single-phase Winding. A single-phase armature winding.

Single-pole Cut-out. A cut-out by means of which the circuit is broken or cut in one of the two leads only.

Single-pole Switch. A switch which opens or closes a circuit at one of its leads only.

Single-throw Switch. A switch having but two positions, one for opening, and the other for closing the circuit it controls, as distinguished from a double-throw switch.

Sinusoidal Alternating Electromotive Forces. Alternating electromotive forces whose variations in strength are correctly represented by a sinusoidal curve. Simple-harmonic E.M.F.'s.

Sinusoidal Curve. A curve of sines. A sinusoid. A curve which to rectangular co-ordinates has an ordinate at each point proportionate to the sine of an angle proportionate to the abscissa.

Skin Currents. A term applied to rapidly alternating currents which are limited to the surface of a conductor.

Skin Effect. The tendency of rapidly alternating currents to avoid the central portions of solid conductors and flow, for the greater part, through the superficial portions. (See page 19.)

Sleeve Joint. A junction of the ends of conducting wires obtained by passing them through tubes, and subsequently twisting and soldering.

Slide Bridge. A bridge whose proportionate arms are formed of a single thin wire, of uniform diameter and of comparatively high resistance, of some material whose temperature coefficient is low.

Sliding Contact. A contact connected with one part of a circuit that closes or completes that circuit by being slid over a conductor connected with another part of such circuit.

Slip of Induction Motor. The proportional difference between the speed of the rotary magnetic field which drives the motor and the speed of the rotor.

Slip of Rotor. The proportional difference between the speed of a rotary magnetic field and the speed of a rotor.

Slotted Armature. An armature provided with slots or grooves for the reception of the wires. An iron-clad armature.

Smooth-core Armature. An armature which presents a continuously smooth cylindrical surface before the armature coils are wound on it. A surface-wound armature as distinguished from an iron-clad armature.

Snap Switch. A switch in which the transfer of the contact points from one position to another is accomplished by a quick motion obtained by the operation of a spring.

Socket. In a telephone switchboard a jack or receptacle for a plug. The barrel of a jack, as distinguished from the contact of the jack placed behind the barrel.

Soft-drawn Copper Wire. Copper wire that is softened by annealing after being drawn.

Solder Ear. An ear or hanger in a trolley system to which the trolley is secured by solder.

Soldering Flux. Any chemical suitable for use in connection with solder to cleanse the surfaces of the articles to be soldered.

Solenoid. A cylindrical coil of wire whose convolutions are circular. An electro-magnetic helix.

South Magnetic Pole. That pole of a magnetic needle which points approximately to the earth's geographical south.

Span Wires. Wires tightly stretched across a street from pole to pole, for the purpose of supporting trolley wires.

Spark Arrester. A device for preventing an arc lamp from scattering sparks or particles of incandescent carbon.

Spark Coil. A coil of insulated wire connected with the main circuit in a system of electric gas lighting, whose extra spark produced on breaking the circuit is employed for electrically igniting gas jets.

Spark, Electric. A term sometimes applied to a disruptive discharge. The phenomena produced by a disruptive discharge in the air-space or gap through which the discharge passes.

Spark Gap. The air-space or gap through which a disruptive discharge passes. A gap forming part of a circuit between two opposing conductors and filled with air or other dielectric, across which a spark passes when a certain difference of potential has been reached.

Sparking of Dynamo-electric Machine. An irregular and injurious operation of a dynamo attended with sparks at its collecting brushes.

Specific Capacity. Specific inductive capacity.

Electrical Dictionary

Specific Conductivity. The particular conductivity of a substance for electricity. The specific or particular resistance of a given length and area of cross-section of a substance, as compared with the same length and area of cross-section of some standard substance. Conductivity with reference to Matthiessen's standard conductivity.

Specific Dielectric Capacity. A term sometimes employed in place of specific inductive capacity.

Specific Energy. Volumetric energy. Energy per unit of volume.

Specific Inductive Capacity. The ability of a dielectric to permit induction to take place through its mass as compared with the ability possessed by a vacuous space of the same dimensions, under precisely the same conditions. The relative power of bodies for transmitting electrostatic stresses and strains, analogous to permeability in metals. The ratio of the capacity of a condenser whose coatings are separated by a dielectric of a given substance, to the capacity of a similar condenser, whose plates are separated by a vacuum.

Specific Magnetic Reluctance. A term sometimes used for specific magnetic resistance.

Specific Resistance. The particular resistance a substance offers to the passage of electricity through it, compared with the resistance of some standard substance. In absolute measurements, the resistance in absolute units between opposed faces of a centimetre cube of a given substance. In the practical system, the above resistance in ohms. Resistivity, expressed in electro-magnetic absolute units as square-centimetres per second. (See page 14.)

Spelter. A name sometimes given to commercial zinc. (See Zinc.)

Spherical Candle=power. The total flux of light emitted by a luminous source divided by 12.566. The candle-power of a point-source, which emits with uniform intensity in all directions, as much light as does an actual lamp. The average candle-power of a luminous source taken in all directions, or considered over the entire surface of an enveloping sphere.

Spider. A radial bracket or support for supporting an armature or machine on a revolving shaft.

Splice Bar. A fish plate employed for connecting together the ends of a rail.

Splicing Ear. A trolley ear for uniting the ends of a trolley wire. A splicing suspension ear.

Splicing Sleeve. A tube of conducting material employed for covering a splice in a conducting wire.

Split Phase. A difference produced between the phases of two or more alternating current into which a uniphase alternating current has divided.

Spring Ammeter. A form of ammeter in which a magnetic core or needle is moved against the action of a spring by the field of the current it is measuring.

Spring Contact. A contact which either opens or closes under the action of a spring. A spring-supported contact, connected with one part of a circuit, that completes the circuit on being moved so as to touch another contact connected with the other part of the circuit. A circuit-closing or circuit-opening device normally maintained in one position and condition by the action of a spring.

Spurious Resistance. A false or apparent resistance arising from the development of a counter-electromotive force.

Square Mil. A unit of area employed in measuring the areas of cross-section of wires, equal to .000001 square inch. A unit of area equal to 1.2732 circular mils.

Standard Ohm. A length of wire having a resistance of the value of one ohm, employed in standardizing resistance coils (See International Ohm.)

Standard Resistance. A known resistance used for comparison with, or determination of, an unknown resistance.

Star Grouping of Polyphase Circuits. A method of grouping a triphase circuit consisting of making a common junction at one point and branching them star-wise.

Star Triphase=winding. A connection of three triphase windings in which all three are connected together at a common point or junction point, and the three free ends connected to the terminals.

Starting Box for Electric Motor. A resistance provided for starting an electric motor.

Starting Current of Motor. The current traversing the coils of a motor at its moment of starting.

Starting Resistance. A resistance employed in the starting box for an electric motor.

Starting Rheostat. Coils of wire mounted in a suitable manner, and so connected as to be successively placed in the circuit of a motor while it is being started.

Starting Torque of Motor. The torque required in starting a motor. The torque developed by a motor in starting.

Static Discharge. A name sometimes given to a disruptive discharge.

Static Electricity. A term applied to electricity produced by friction.

Static Voltmeter. A voltmeter operating by electrostatic action, as opposed to a voltmeter operating electro-magnetically. A voltmeter in which the moving system is displaced by electrostatic forces. A voltmeter of the electroscope or electrometer type.

Station Indicator. A name sometimes given to a station voltmeter. Any indicator situated at a central station.

Station Load. The total load existing on a central station at any time.

Stationary Motor. A motor that is fixed in place in contradistinction to a locomotor.

Stator. The stationary member, whether primary or secondary, of any alternating-current machine.

Stay Rod. A rod of iron or steel, used to stay or support a telegraph or telephone pole.

Steady Current. A current whose strength does not vary from time to time.

Step=down Converter. A stepdown transformer.

Step=down Transformer. A transformer in which a small current of comparatively great difference of potential is converted into a large current of comparatively small difference of potential. An inverted Ruhmkorff induction coil.

Step Rate. Method of charging for electric service at definite successive rates per kilowatt-hour consumed. Each rate applying to the entire quantity purchased during the period covered. As, for example, during each month ten kilowatt-hours or less at 15 cents per kilowatt hour. If over ten kilowatt-hours and less than 20 kilowatt-hours are used all are charged for at 12 cents per kilowatt-hour. If 20 or more kilowatt-hours are registered during the month, all are charged for at 10 cents per kilowatt-hour.

Step=up Transformer. A transformer in which a large current of comparatively small difference of potential is converted into a small current of comparatively great difference of potential.

Storage Battery. A number of separate storage cells connected so as to form a single electric source.

Storage Cell. Two relatively inert plates of metals or metallic compounds immersed in an electrolyte incapable of acting on them until after an electric current has been passed through the liquid from one plate to the other and has thus changed their chemical relations. One of the cells required to form a secondary battery. A term sometimes given to the jar containing a single cell.

Electrical Dictionary

Straight-line Trolley Hanger. A trolley-hanger employed on a straight trolley line, suitably supported by a span wire so as to have a vertical strain only.

Strain. Any change of size or shape, any deformation.

Strain Insulator. An insulator used for the double purpose of taking the mechanical strain at a bend or at the end of a conductor, and also insulating the same electrically.

Stranded Conductor. A conductor formed of a number of smaller interlaced or twisted conductors, either for the purpose of reducing self-induction, or eddy currents, or for increasing its flexibility.

Strap Copper. Copper conductors formed of bars or straps, employed in connection with a bar-armature winding.

Stray Currents. A term sometimes used for eddy currents.

Stray Field. Leakage magnetic flux. That portion of a magnetic field which does not pass through an armature or other magneto-receptive device.

Strength of Current. A general term for the magnitude of the current in a circuit. Amperage.

Stress. Any action between two bodies that causes a strain, or deformation.

Striking an Arc. Separating the carbon electrodes for the formation of an arc between them.

Sub-mains. Conductors which branch off from the mains. Mains which are themselves branches of mains.

Sub-marine Cable. A cable designed for use under water, generally under the ocean.

Sub-station. An auxiliary station.

Subway, Electric. An accessible underground way or passage provided for the reception of electric-light wires or cables.

Supply Mains. A term sometimes applied to the mains in a system of incandescent light or power distribution.

Surface Density. The quantity of electricity-per-unit-of-area at any point on a charged surface.

Surging Discharge. A discharge accompanied by electric surgings. An oscillatory discharge.

Surgings, Electric. Electric oscillations set up in a conductor that is undergoing rapid discharging, or in neighboring conductors that are being rapidly charged and discharged. Electric oscillations, direct or induced.

Switch. Any device for readily opening or closing an electric circuit. In telephony, a name sometimes given to a switchboard.

Switch Blade. A conducting strip or knife-blade of a switch.

Switch-board. A board, slab or frame of insulating material, upon which are supported conducting bars, pieces, frames or masses, with or without switches and instruments, for the ready establishment of electrical connections between circuits connected therewith.

Symmetrical Alternating Current. Any alternating current whose successive semi-periods, waves, or alternations passes opposite but equal values, or correspond in all respects save in direction.

Synchronism. Unison of frequencies in alternating-current systems or apparatus. Generally, the co-periodicity and co-phase of two periodically recurring events. The coincidence in cyclic recurrence of two or more periodic variables, without regard to amplitude.

Synchronous Compensator. A synchronous machine, running either idle or under load, whose full excitation may be varied so as to modify the power-factor of the circuit, or through such modification, to influence the voltage of the circuit.

Synchronism Indicator. A phase indicator. A device for indicating the phase relation or the condition of synchronism between two or more periodic quantities.

Synchronous Converter. A machine which converts from an alternating to a direct current, or vice versa, commonly called a rotary converter.

Synchronous Generator. A generator of alternating currents, operating or capable of operating in synchronism with another generator.

Synchronoscope. A synchronizing device which, in addition to indicating synchronism, shows whether the machine is synchronized fast or slow.

T.

T,t. A symbol employed for time.

Tachometer. An apparatus for indicating at any moment on a dial the number of revolutions per minute of a shaft or machine with which it is connected. A speed indicator.

Tangent Galvanometer. An instrument in which the deflecting coil consists of a coil of wire within which is placed a needle, supported at the center of the coil, and very short by comparison with the diameter of the coil.

Tap. A conductor attached as a shunt to a larger conductor. A derived circuit for carrying off a share of the main current. A wire taken from the junction between the short and long sections of a quadruplex battery.

Taping. Covering a wire or a joint with an insulating tape. A covering of tape applied to a cable sheathing.

Tapping a Circuit. Introducing a loop or branch in a telegraphic or telephonic circuit, for the purpose of intercepting the messages sent over the circuit.

Taps. A general term employed, in a system of incandescent lamp distribution for branches or sub-branches that are carried from the mains into the rooms of a building or to the fixtures in the halls.

Teaser, Electric. A coil of fine wire placed on the field magnets of a dynamo in a shunt across the main circuit, in addition to the field magnet series coil. A series coil placed on a field magnet, in addition to a regular shunt field, for the purpose of preliminary excitation.

Tel-autograph. A telegraphic system for the fac-simile reproduction of writing at a distance.

Telegraph. A general name for the instrument or combination of instruments employed for conveying a communication or despatch to a distance by means other than that of the unassisted voice. A general term for any apparatus employed in telegraphy.

Telegraph, Electric. A general term for any apparatus employed in electric telegraphy.

Telegraph Loop. A pair of wires extending from a telegraphic station to a branch office.

Telegraphic Cable. A cable designed to establish telegraphic communication between different points.

Telegraphic Ground-circuit. An earth circuit used in any system of telegraphy.

Telegraph Interrupter. A device for making and breaking a circuit at a definite rate. A telegraphic key, or other analogous device.

Telegraphic Key. The key employed for sending over the line successive makes-and-breaks corresponding to the dots and dashes of the Morse alphabet, or to the deflections of the needle in a needle telegraph.

Telegraphic Repeater. Any telegraphic device whereby the relay, sounder or registering apparatus is caused to repeat into another circuit the signals received. An apparatus for maintaining telegraphic communication between two circuits not in conductive connection.

Telegraphone. An instrument whereby the indentations on the cylinder of a graphophone can be reproduced upon another cylinder at the same time that the vocal sounds represented by the indentations are being rendered audible.

Electrical Dictionary

Telegraphy. Any system by means of which a communication or despatch is transmitted to a distance, by means other than that of the unassisted voice.

Telephone. To communicate by means of a telephone.

Telephone. An instrument for the electric transmission of articulate speech.

Telephone Cable. A cable, either aerial or subterranean, suitable for the transmission of telephonic despatches. Generally a cable whose conductors are twisted in pairs, for the purpose of avoiding the disturbance produced by cross-talk.

Telephone Call-wire. A wire employed in certain telephone systems, by the subscriber, for the purpose of calling the central office. A special calling wire in a telephone system.

Telephone Exchange. A central office provided with circuits, switches and other devices, by means of which any one of a number of subscribers, connected either directly or indirectly with the exchange, may be placed in communication with any other subscriber, or with some other exchange.

Telephone Head-gear. Any apparatus placed on the head for readily attaching a telephone receiver to the ear of the operator.

Telephone Indicator. An indicator employed on a telephone circuit to indicate the number of the correspondent calling. A telephone drop annunciator.

Telephone Meter. An apparatus employed on telephone circuits for registering the number of connections between subscribers and the time or duration of the same. A calculagraph.

Telephone Set.—A general term for the apparatus employed by a telephone subscriber at his office.

Telephonic. Of or pertaining to a telephone.

Temperature. State of matter in respect to heat.

Temperature Coefficient. A coefficient of variation in a quantity, per degree of change in temperature. The coefficient by which a change of temperature must be multiplied in order to arrive at the change in a quantity due to the change of temperature.

Tension, Electric. A term loosely applied to signify indifferently surface density, electromotive force, electromotive intensity, dielectric stress, or difference of potential.

Terminal Board. A small switchboard situated on a dynamo.

Terminal Insulator. An insulator at the terminus of a line. A telegraph line insulator provided with two grooves for the reception of two ends which may be kept insulated from each other.

Terminal Voltage. The terminal electromotive force.

Terminals. A name differently applied to the poles or to the electrodes of a voltaic battery.

Terrestrial Magnetism. A name applied to the magnetism of the earth.

Tesla Coil. A form of oil-insulated induction coil or transformer.

Test Wires. The wires in a multiple telephone switch-board, by which the busy test is made. Any wires or circuits used in making a test. Wires to be tested or undergoing a test.

Testing Jacks. In a multiple telephone switch-board, or distributing board, special jacks sometimes inserted in any circuit for testing such circuits.

Testing Switch. In a quadruplex telegraphic system, a switch for throwing the line from the sending battery to ground through a suitable resistance, for the purpose of enabling the distant station to obtain a balance.

Theater Dimmer. A dimmer employed in theaters for varying the intensity of the illumination. A rheostat or choking coil employed in a theater-lighting circuit.

Thermal Activity. The activity possessed by a body, arising from its heat energy. The rate of doing thermal work.

Thermo-electric Battery. A combination, as a single thermo-electric source, of a number of separate thermo-electric cells or couples.

Thermo-electric Cell. A name applied to a thermo-electric couple.

Thermo-electric Couple. Any two dissimilar metals which, when connected at their ends only, so as to form a complete electric circuit, will produce an electric current when one end is more highly heated than the other.

Thermo-electric Current. A current produced by a thermo-electromotive force.

Thermo-electric Junction. A junction of a thermo-electric couple.

Thermo-electric Pile. A thermo-electric battery.

Thermo-electricity. The electromotive force developed by a thermo-electric cell or battery. Electricity produced by differences of temperature at the junction of dissimilar metals.

Thermometer. Any apparatus for measuring temperature.

Thermometer, Electric. A device for determining the effects of an electric discharge by the movements of a liquid column due to the expansion of a confined mass of air through which the discharge is passed.

Thermo-pile. A thermo-electric battery.

Thermostat. An instrument for automatically maintaining a given temperature by closing an electric circuit through the expansion of a solid or liquid.

Thomson Effect. The production of an electromotive force in unequally heated homogeneous conducting substances. The increase or decrease in the difference of temperature in an unequally heated conductor, produced by the passage of an electric current through the conductor.

Three-phase Armature. An armature possessing a three-phase winding.

Three-phase Circuit. Any circuit suitable for the transmission of three-phase currents.

Three-phase Currents. Three alternating-currents differing in phase from one another by one-third of a cycle.

Three-phase Generator. Any generator capable of producing three-phase currents.

Three-phaser. A three-phase generator.

Three-phase Meter. A meter suitable for operation on a three-phase system, for recording the energy delivered on all three branches.

Three-phase Motor. Any motor suitable for operation by three-phase currents.

Three-phase Transformer. Three separate transformers employed for the transformation of triphase currents.

Three-phase Transmission. Transmission by means of three-phase currents.

Three-way Switch. A three-point switch.

Three-wire Circuit. A circuit employed in a three-wire system. A three-wire diaphase system. A three-wire triphase system.

Three-wire Mains. The mains employed in a three-wire system of distribution.

Three-wire System. A system of electric distribution for lamps or other multiple-connected translating devices, in which three conductors are employed in connection with two dynamos connected in series, the central or neutral conductor being connected to the junction of the dynamos, and the two other conductors to the remaining free terminal of each.

Three=wire Transmission. Transmission by the three-wire system. Transmission by means of the three-wire diphase or three-wire triphase systems.

Throw=over Switch. A switch for readily and rapidly changing a circuit from one source to another or one system to another. A switch which is thrown over from one set of contacts to another, by movement about an axis.

Tie=wire. Binding wire of an insulator. Wire which binds an overhead wire to the groove of its insulator.

Time=constant of Circuit. The time in which a current will fall in a circuit when the E.M.F. is suddenly removed, in a ratio whose Naperian logarithm is unity. The ratio of the inductance of a circuit to its resistance.

Time Cut=out. An automatic cut-out arranged so as to permit a translating device to operate for a certain time, after which it is cut out of the circuit.

Time Switch. A switch arranged to open or close a circuit at a certain time or after the lapse of a certain time. An automatic switch in which a predetermined time is required either to insert a resistance into or remove it from a circuit.

Torque. The moment of a force applied to a dynamo or other machine which causes its rotation. The mechanical rotary or turning force which acts on the armature of a dynamo-electric machine, or motor, and causes it to rotate. The ratio of the mechanical activity of a motor, at its belt or pulley, to the angular velocity.

Torsion Galvanometer. A galvanometer in which the strength of a deflecting current is measured by the torsion exerted on the suspension system.

Tractive Effort. The torque in pounds developed at the rim of the wheels divided by total train weight in tons. This term is usually expressed in pounds per ton of train weight and includes train resistance losses.

Transformer. A stationary piece of apparatus for transforming, by electro-magnetic induction, power from one circuit to another, or for changing, through such transformation, the values of the electromotive force.

Transformer=Balancer. An auto-transformer for dividing a voltage in constant proportions, and usually into two equal portions.

Transformer Stampings. Sheet steel stampings of such shape as is suitable for building up the laminated core of a transformer.

Transmission Circuit, Electric. The circuit employed to receive the apparatus necessary in any transfer of electric energy from the generators to the receptive devices. In alternating-current constant-potential transmission circuits the following average voltages are in general use. 6,600, 11,000, 22,000, 33,000, 44,000, 66,000, 88,000, 110,000.

Transmission, Electric. The transference of energy from one point to another by means of electric currents.

Transmission Line. A transmission circuit.

Transmitter, Electric. A general name applied to the various electric apparatus employed in telegraphy or telephony to transmit or send electric impulses over a line wire or conductor. Any electric-transmitting instrument, as distinguished from a receiving instrument.

Transposing. In a system of telephonic communication, a device for avoiding the bad effects of mutual induction, by alternately crossing equal lengths of consecutive sections of the line.

Travelling of Arc. An unsteadiness produced in the light of a carbon arc occasioned by the shifting of the position of the arc between the electrodes.

Triphase. A word frequently employed for three-phase

Triphase=current A three-phase current

Triple Petticoat Insulator. An aerial line insulator provided with a triple petticoat.

Triple=pole Switch. A switch consisting of a combination of three separate switches for opening or closing three circuits at the same instant A switch employed to open or close three contacts. A switch employed to open or close triphase circuits.

Trolley. A rolling contact-wheel that moves over a trolley line and carries off the current required to drive the motor cars.

Trolley Ear. A metal piece supported by an insulator, to which the trolley wire is fastened.

Trolley Hanger. A device for supporting and properly insulating a trolley wire.

Trolley Insulator. A name sometimes applied to a trolley ear.

Trolley Switch. A switch placed on a track for the purpose of changing the car from one track to another. An overhead switch provided at a turn of a trolley load for guiding the trolley to another line when the frogs on the track beneath have thrown the wheels of the car into another track.

Trolley Wire. The bare overhead wire employed in a trolley system for supplying the driving current to the car motors through the intervention of the trolley mechanism. (See Index.)

True Watt. The activity in an alternating-current circuit, as given by the reading of a correctly calibrated wattmeter connected with such circuit.

Trunk=line Wires. Through wires extended between two distant stations, provided with receiving and transmitting instruments at their ends only. In telephony, main line wires connecting two terminal offices for connection to sub-offices or subscribers. A main line wire connecting two important terminals for receiving telephone traffic.

Turbo=generator. A steam turbine coupled to an electrical generator.

Twin Conductors. Two parallel conductors, laid side-by-side, and covered by a simple coating of braid.

Twin=wire Circuit. A circuit formed of twin conductors.

Twisted Pair Cable. A cable containing one, several, or many twisted pairs of conductors, suitable for metallic circuits.

Twisted Pairs of Conductors. An assemblage of twisted pairs of conductors, for metallic circuits.

Twisted Wires. A term sometimes employed for transposed aerial telephone wires.

Two=circuit Armature=winding. An armature winding which provides only two circuits through an armature between the commutator brushes, no matter how great may be the number of poles.

Two=circuit Dynamo. A dynamo provided with a two-circuit armature winding.

Two=phase Armature. A diphase armature.

Two=point Switch. A switch by means of which a circuit can be completed through two different contact points.

Two=way Switch. A switch provided with two contacts connected with two separate and distinct circuits.

Two=wire Mains. A name for the mains employed in the ordinary system of multiple distribution, as distinguished from a three-wire main, or that used in a three-wire system.

Electrical Dictionary

U.

Underground Cable. A cable suitable for being placed underground.

Underground-cable Terminal. The place where a cable emerges from the ground. A cross-connecting or distributing board placed where an underground cable enters or leaves the ground, in order to facilitate the making and changing of the connections.

Underground Conductor. An electric conductor placed underground, either by actual burial or by passing it through underground conduits or subways.

Underground Electric Conduit. See Conduit, Electric.

Uni-directed Currents. Currents that have been caused to take the same direction by means of a commutator.

Uniform Potential. A potential whose value does not vary from point to point. A constant potential.

Uniphase. Single phase.

Unipolar. Possessing a single pole.

Unipolar Armature. A dynamo-electric machine armature whose polarity is not reversed during its rotation in the field of the machine.

Unipolar Magnet. A term proposed for a magnet in the shape of a long bar, one pole of which lies in the axis of rotation, the axis being placed near to the other pole which is balanced by a counterpoise.

Universal Switch. A pin switchboard composed of horizontal and vertical metallic bars capable of inter-connection by means of pins.

Unvarying Current. A current whose strength does not vary from time to time. A current of constant strength and direction.

Upper Harmonics of Current. The higher frequencies of a simple-periodic or alternating current.

V.

V. A contraction for volt.

V. A contraction sometimes used for velocity.

Vacuum Tubes. Glass tubes in which the air or other gas has been partially removed, and through which electric discharges are passed for the production of luminous effects. A name sometimes applied to Crookes, Roentgen, or other high-vacuum tubes.

Variable Resistance. A resistance, the value of which can be readily varied or changed. An adjustable resistance.

Vector. A direct quantity. A quantity possessing both direction and magnitude.

Vector Diagram. A diagram representing the relations of vector quantities.

Vector Quantity. A quantity possessing both direction and magnitude.

Vector Sum. The geometrical sum of two or more vector quantities.

Ventilated Armature-windings. Armature windings provided with means for cooling by forcing currents of air over them.

Vernier Wire-gauge. A micrometer wire-gauge.

Virtual Amperes. Amperes measured in an alternating-current as the square root of the mean square of the current, and determined by an ammeter calibrated by constant currents. Effective amperes.

Virtual Counter Electromotive Force. Effective C.E.M.F. in an alternating-current circuit.

Virtual Current. The virtual amperes.

Virtual Resistance. The apparent resistance of a circuit.

Volt. The practical unit of electromotive force. Such an electromotive force as is induced in a conductor which cuts lines of magnetic flux at the rate of 100,000,000 per second. Such an electromotive force as would cause a current of one ampere to flow against a resistance of one ohm. Such an electromotive force as would charge a condenser of the capacity of one farad with a quantity of electricity equal to one coulomb. 10^8 absolute electro-magnetic units of electromotive force. (See International Volt.)

Volt-ampere. The watt.

Voltage. The value of the electromotive force or difference of potential of any part of a circuit, expressed in volts.

Voltaic Arc. See Arc, Voltaic.

Voltaic Battery. The combination as a single source of a number of separate voltaic cells.

Voltaic Cell. The combination of two metals, or of a metal and a metalloid which, when dipped into a liquid or liquids called electrolytes, and connected by a conductor, will produce a current of electricity. A voltaic couple and its accompanying electrolytes.

Voltaic Couple. Any two materials, generally dissimilar metals, which are capable of acting as an electric source when dipped into an electrolyte.

Voltaic Electricity. The difference of potential produced by a voltaic cell or battery.

Voltaic Elements. Two metals or substances which form a voltaic couple.

Voltaic Pile. A word sometimes used for voltaic battery.

Voltameter. An electrolytic cell employed for measuring the quantity of electric current passing through it, by the amount of chemical decomposition affected in a given time.

Voltmeter. Any instrument employed for measuring differences of potential.

A volt meter may be constructed on the principle of a galvanometer, in which case it differs from an ammeter, or ampere meter, which measures the current, principally in that the resistance of its coils is greater, and that in an ampere meter the coils are placed as a shunt to the circuit.

In the ordinary operation of a voltmeter, the action of the current in passing through a coil of insulated wire is to produce a magnetic field, which causes the deflection of a magnetic needle. Since the resistance of the voltmeter is constant, the current passing, and hence the deflection of the needle, will vary with the value of the voltage. The magnetic field produced by the current deflects the magnetic needle against the action of another field, which may be either the earth's field, or an artificial field produced by a permanent or an electro-magnet. Or, it may deflect it against the action of a spring, or against the force of gravity acting on a weight. There thus arise varieties of voltmeters, such as permanent-magnet voltmeters, spring voltmeters, and gravity voltmeters.

Voltmeter Compensator. A device used in connection with a voltmeter to reduce its reading by the amount of the line drop, and thus cause it to indicate the voltage delivered at the end or at any other predetermined point of the line.

Vulcanite. A variety of vulcanized rubber, possessing high powers of insulation and specific inductive capacity. Ebonite.

Vulcanized Fibre. A variety of insulating material suitable for purposes requiring the highest insulation.

W.

W. A contraction for watt.

W.P. A contraction for waterproof, or weather-proof.

w.h. An abbreviation for watt-hour, a practical unit of electric energy.

Wall Bracket. An insulator bracket attached to a wall. A more or less ornamental support for one or more incandescent lamps attached to the wall of a room, hall or corridor.

Wall Socket. A socket placed in a wall and provided with openings for the insertion of a wall plug with which the ends of a flexible twin-lead are connected.

Water=proof Wire. Wire covered by a water-proof material.

Water Rheostat. A rheostat whose resistance is obtained by means of a mass of water between the electrodes.

Watt. A unit of electric power. A volt-ampere. The power developed when 44.25 foot-pounds of work are done in a minute, or 0.7375 foot-pound of work is done in a second. (See International Watt.)

Watt=hour. A unit of electric work. A term employed to indicate the expenditure of an electric power of one watt for an hour.

Watt=hour Meter. An instrument for registering total watt-hours.

Wattless Component Indicator. A device for measuring the product of voltage of a circuit, and the component of current at 90 degrees with the voltage. This product is the heating effect in excess of the heating that would be given by a circuit of the same voltage and power at 100 per cent load-factor. The device is a wattmeter with coils connected to measure volts times current at 90 degrees from the voltage phase.

Wattless Component of Current. In an alternating-current circuit, that component of the current which is in quadrature with the impressed E.M.F. and which, therefore, takes from or gives no energy to the circuit. In an alternating-current circuit the product of the E.M.F. and the effective susceptance.

Wattless Component of Electromotive Force. In an alternating-current circuit, that component of the E.M.F. which is in quadrature with the current strength, and, therefore, does no work on the current. In an alternating-current circuit the product of the current and the effective reactance.

Wattless Current.—That component of an alternating electric current which is in quadrature with the pressure and which, therefore, does no work. The idle current. In an alternating-current circuit the product of the effective susceptance and the E.M.F.

Wattless E.M.F. The wattless component of E.M.F. in an alternating-current circuit. The reactive E.M.F., as distinguished from the active E.M.F. of an alternating-current circuit. In an alternating-current circuit, the product of the E.M.F. and the effective or apparent conductance.

Wattmeter. An instrument for measuring the power in any circuit.

Wave, Electric. An electric periodic disturbance in an elastic medium.

Wave Winding. Undulatory winding. Continuous winding. A winding which, when developed, has the form of a wave.

Weather=proof Insulation. A trade-name for a character of insulation consisting of one or more layers of braided material soaked in an insulating compound. (See Index.)

Weather=proof Wire. A wire provided with weather-proof insulation. (See Index.)

Weber. The practical unit of magnetic flux. A unit of magnetic flux having the value of one absolute unit or line. A term proposed by Clauius and Siemens, but not adopted, for a magnetic pole of unit strength.

Weber Turns. Flux linkages in C.G.S. units of flux and the turns through which they pass.

Weight=per=mile=ohm. A standard of conductivity of wires. The weight per mile of a wire, multiplied by its resistance per mile at a given temperature. (See page 15.)

Welding, Electric. Effecting the welding union of metals by means of heat of electric origin.

Welding Transformer. A low voltage step-down transformer employed in electric welding.

Wheatstone's Electric Bridge. A Wheatstone's electric balance.

Windings. A general name applied to the coils placed on an armature of a dynamo or motor, or on the core of an electro-magnet.

Wire. A conductor that forms part of a circuit. A telegram.

Wire Core. A form of laminated core obtained by the use of a number of iron wires.

Wire Splice. A splice effected between two pieces of wire.

Wireless Telegraphy. A general term for any form of telegraphic communication which can be effected without wire circuits. Induction telegraphy. Conduction telegraphy through the medium of the earth.

Wiring. Placing or installing the wires required in any circuit. Collectively, the wires or electric conductors employed in any circuit of electric distribution.

Work. The product of force by the distance through which it acts.

Work, Electric. The joule. A volt-coulomb, or the work done by the passage of one conduct through one volt.

Working Current. In an alternating-current circuit, a name sometimes given to an active current, or that component of the current which is in phase with the pressure. Any current in a circuit which does work. A current operating a translating device.

Working Speed of Cable. A term employed for the number of signals that can be sent over a cable in a given time.

X

X=ray Tube. A name sometimes given to a Roentgen ray tube.

X=rays. A name frequently given to X-radiation. The invisible rays emitted by an electrically excited Crookes tube, and which are capable of penetrating many substances opaque to light, and of producing actinic or fluorescent effects. The unknown rays emitted by an X-ray tube from some point generally opposite the cathode, which receives cathode-ray bombardment.

Y.

Y=connected Three=phase Armature. A triphase armature having three circuits connected to a common point. A star-connected triphase armature.

Y=connector. A connector resembling the letter Y in shape for joining a conductor to two branch wires.

Y=current. The current between any wire of a triphase system and the neutral point.

Z.

Zeeman Effect. The broadening of the lines in the spectrum of a heated substance when placed in the flux of a powerful magnetic field.

Zero Method. Any method employed in electrical measurement, in which the value of the electromotive force, the resistance, current or other similar quantities, are determined by balancing against such quantities equal values of the same units, and ascertaining the equality not by the deflection of a needle of a galvanometer or electrometer, but by the absence of such deflections. A null method.

Zero Potential. An arbitrary potential-level from which electric levels are measured. The earth's potential.

Zinc, Zn. At. wt. 65. Sp. gr. 7.14. Melts at 780° F. Volatilizes and burns in the air when melted, with bluish-white fumes of zinc oxide. It is ductile and malleable but to a much less extent than copper, and its tenacity, about 5000 to 6000 lbs. per square inch, is about one-tenth that of wrought iron. It is practically non-corrosive in the atmosphere, a thin film of carbonate of zinc forming upon it. Cubical expansion between 32 and 212 F., 0.0088. Specific heat .096. Electric conductivity 29, heat conductivity 36, silver being 100. Its principal uses are for coating iron surfaces, called "galvanizing," and for making brass and other alloys. (Kent.)

Zinc Currents. A term sometimes used for negative currents.

Zinc Plating. Electro-plating with zinc Galvanizing.

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Index

Page
Advances on Annunciator Wire . . 94
  Bare Copper Cables 65
  Magnet Wire 86
  Office Wire 95
  Weatherproof Wires and Cables 100–101
Alternating Current Heating Effects . 19
Aluminum, Physical Properties of . 14
American Special Brewery Cord . . 113
American Steel and Wire Gauge . . 22
Annunciator Wire 94, 96
Annunciator Wire, Black Core . . 94
Annunciator Wire, Damp-proof . . 94
Annunciator Wire, Special . . . 96
Asbestos and S. C. C. Magnet Wire . 89
Armature Binding Wire . . . 80–81
Armor Wire for Cables . . . 81, 149
Automobile Ignition Wires and Cables 145
Automobile Lighting Cord . . . 111

Bare Wire and Cables 58–82
Bare Copper Wire and Cables . . 64
Bare Copper Wire Advances . . . 64
Binding Wire, Armature . . . 80–81
Birmingham Wire Gauge 22
Black Core Annunciator Wire . . 94
Black Core Office Wire 95
Black Finish, Slow Burning Wires . 106
Bond Wire, Extra Galvanized . . 74
Bonds, Rail 67–70
Braiding Machine 99
Braiding for Rubber Insulation . . 120
Braiding for Weatherproof Wires . 99
Brewery Cord 132
Brewery Cord, American Special . . 113
Bridle Wire, Telephone 129
Brown & Sharpe Gauge . . . 21–22
Border Light Cables 132
Bunched Strand 27

Cable Joints 176, 180–181
Cables 27–35
  Bare Copper Advances 65
  Bare Wire and 58–82
  Border Light 132
  Car 138
  Concentric 32
  Deck 132

Page
  Duplex Concentric Mining Machine 139–140
  Elevator Control 132
  Elevator Lighting 132
  Extra Flexible 66
  Hemp Core 65–67
  Joining of 176–177, 180–181
  Mining Machine 139–140
  Submarine 164
  Theater or Stage 133
  Varnished Cambric 163
Calories 16
Cambric Cables, Varnished . . . 163
Canvasite Cord 113
Car Cables 138
Carrying Capacities of Conductors 16–18
Catenary Construction 60–63
Catenary Wire 77
Chemical Laboratories . . . 120–121
Circles, Properties of 54–56
Circular Mils 21
Clamp, Three-bolt Strand 79
Clamp, Crosby Wire Rope . . . 79
Coils, Dimensions of 48–49
Coils, Stringing Wire from . . 46–47
Coils of Wire 45–49
Coils, Weatherproof Wires and Cables 102
Conduit Systems 167
Cord, American Special Brewery . . 113
  Automobile Lighting 111
  Brewery 132
  Canvasite 113
  Electric Heater 114
  Lamp 108–109
  Packing House 131
  Reinforced Portable 110
Cord for Portables 111
Compound Strand 32–35
Concentric Cables 32
Conductance and Resistance . . . 12
Conductivity 12–13
Conductors, List of 12
Contents 8
Control Cable, Elevator 132
Conversion Tables 52–56
Copper 12, 14, 35
Copper Couplings 175

Page
Copper, Impurities in 39
Copper, Telephone and Telegraph Wire 64
Copper, Physical Properties of 14
Copper Wire Advances 65
Cotton-covered Magnet Wire 85–87
Cotton-covered Special Magnet Wire 91
Cotton Yarn 85
Couplings, Copper 175
Crosby Wire Rope Clip 79
Crown Duplex Wires and Cables 137
Crown Feeder Cables 136
Crown Fireproof Cables 138
Crown Flexible Cables 136
Crown Lead-covered Cables 150–154
Crown Rubber-insulated Wires and Cables 133–140
Crude Rubber 116
Cutting Wire to Lengths 65

Damp-proof Annunciator Wire 94
Damp-proof Office Wire 95
Data, Tabulated 52–56
Data, General 12–56
Deck Cables 132
Diameters, Rubber-covered Wires and Cables 146
Dictionary, Electrical 183
Dielectric 20
Dielectric Hysteresis 20
Dimensions of Coils, Standard 48–49
Drawing Cables into Ducts 173
Drawing Wire 42–43
Drop Wire, Telephone 131
Duplex Concentric Mining Machine Cables 139–140
Duplex Wires and Cables, Crown 137
Duplex Wires and Cables, Globe 127

Electric Heater Cord 114
Electrical Dictionary 183
Electrical Laboratories 120–121
Elevator Control Cable 132
Elevator Lighting Cable 132
Elongation of Copper Wire 43–44, 67
Extra High Strength Steel Strand 76–78

Facilities 9
Feeder Cables, Crown 136
Feeder Cables, Globe 126

Page
Fireproof Cables, Crown 138
Fixture Wire, Globe 128
Flexible Cables, Crown 136
Flexible Cables, Extra 66
Flexible Cables, Globe 126
Foucoult or Eddy Current Loss 20

Galvanizing Wire 44, 72
Galvanized Bond Wire, Extra 74
Galvanized Steel Signal Wire 75
Galvanized Telephone and Telegraph Wire 71
Gauges, Wire 21–22
General Data 12–56
Globe Duplex Wires and Cables 127
Globe Feeder Cables 126
Globe Fixture Wire 128
Globe Flexible Cables 126
Globe Insulated Telephone Wire 128–131
Globe Rubber Insulated Wires and Cables 124–133
Grade A, Lamp Cord 108–109
Grade C, Lamp Cord 109

Handling Lead Cables 167
Heater Cord, Electric 114
Heating Effects, Alternating Current 19
Heating of Conductors 16, 19
Hemp Cord Cables 65–67
High Strength Steel Strand 76, 78
High Strength Steel Strand, Extra 76, 78
Hysteresis, Dielectric 20

I^2 R Loss 19
Ignition Wires and Cables, Automobile 145
Inquiries Concerning Cables 149–150
Inside Telephone Wire 129
Installation of Underground Cables 166–181
Insulation, Rubber 116–119
Insulation, Weatherproof 99
International Ohm 13
Iron, Physical Properties of 14
Iron and Steel 39–42
Iron and Steel Telephone and Telegraph Wire 71–74
Iron Wire, Weatherproof 102–103

Jointing of Cables 176–177
Jointing Materials 178
Joints in Galvanized Telephone and Telegraph Wire 73

Page
Joints in Hard Drawn Copper 67
Joints in Magnet Wire 92
Joints of Lead Cables 180–181
Jumper Wire, Telephone 131

Laboratories, Electrical and Chemical 120–121
Lagging for Reels 50
Lamp Cord 108–109
Lamp Cord Products 108–114
Lamp Cord, Grade C 109
Lamp Cord, Grade A 108–109
Lay or Pitch of Strand 28–29
Lead-covered Cables, Crown 150, 154
Lead-covered Cables, Inquiries Concerning 149–150
Lead-covered Cable, Rubber Insulated 150, 154
Lead Encased Wires and Cables 148, 166
Lead Sheaths 148
Lead Sheathed Cables, Paper Insulated 155–162
Lengths, Cutting Wire to 65
Lightning Protection for Transmission Lines 77
List of Products 227

Magnet Wire 84–91
Magnet Wire, Asbestos and S. C. C. 89
Magnet Wire, Cotton-covered 85–87
Magnet Wire, Paper-covered 91
Magnet Wire, Rectangular 89–90
Magnet Wire, Silk Covered 88
Magnet Wire, Special C. C 91
Magnet Wire, Square 90
Magnetic-core Steel, Silico 82
Manholes 168–170
Manufacture of Wire 35–44
Messenger Strand 76
Metric Tables 52–53
Micrometer Screw 21
Mil-foot Ohms per 15, 17
Mils 21
Mils, Circular 21
Mining Machine Cables 139–140

National Electric Code Rules for Rubber-covered Wire 122
National Electric Code Rules for Weatherproof Wire 99

Page
Non Conductors, List of 12

Office Wire 95
Office Wire, Black Core 95
Office Wire, Damp-proof 95
Office Wire, Special 96
Ohm, International 13
Ohms per Mil-foot 14–15, 17
Orders, Regarding 10
Outside Distributing Telephone Wire 128

Packing and Shipping 44–51
Packing House Cord 131
Paper-covered Magnet Wire 91
Paper-insulated Lead Sheathed Cables 155, 162
Paper-insulated Lead-covered Cables, Specifications for 157, 159
Physical Data 55–56
Physical Properties of Conductors 14
Pitch or Lay of Strand 28–29
Pole Data, Telephone and Telegraph 74
Pole Steps 81–82
Portable Cord, Reinforced 110
Portables, Cord for 111
Pot Head Telephone Wire 129
Pounds per Mile ohm of Copper 15, 19
Products, Lamp Cord 108–114
Products, List of 227
Protection of Insulation 120

Racks for Cables 171
Rail Bonds 67
Rail Bond Tools 70
Rectangular Magnet Wire 89–90
Reels 49–50, 65
Reels, Lagging 50
Regarding Orders 10
Reinforced Portable Cord 110
Reliance Weatherproof Iron Wire 102–103
Reliance Weatherproof Wires and Cables 98–105
Resistance 13
Resistance, per Mil-foot of Copper 15, 17
Resistance, of Copper Strand 32
Resistance, Resistivity 13–15
Resistance, Specific 14
Resistance Wire 80
Rodding Sticks 173
Rope Strand 32, 35

Page

Rubber Compound 116, 119
Rubber-covered Iron Telephone Wire 130
Rubber-covered Wires and Cables 116–145
Rubber, Crude 116
Rubber Insulation 116–119
Rubber-insulated Lead-covered Cables 150–154
Rubber-insulated Wires and Cables, Crown 133–140
Rubber-insulated Wires and Cables, Diameters and Weights 146
Rubber-insulated Wires and Cables, Globe 124–133
Rubber-insulated Wires and Cables, Thirty Per Cent. 140–145
Rubber Tape 120

Sales Offices 4
Seals for Galvanized Telephone and Telegraph Coils 71
Semaphore Wire 75
Shipping of Rubber-covered Wire 124
Shipping of Weatherproof Wires and Cables 44, 102–103
Siemens Martin Steel Strand 76, 78
Signal Wires and Cables 143–145
Signal Wire, Extra Galvanized Steel 75
Signal Wires and Cables, Specifications for 144–145
Silico-Magnetic-Core Steel 82
Silk Thread 85
Silk-covered Magnet Wire 88
Skin Effect 19–20
Slow Burning Wires and Cables 104
Slow Burning Wires, Black Finish 106
Snake Wire 173
Special Magnet Wire, Cotton-covered 91
Special Weatherproof and Slow Burning Wires 105–106
Specifications for Cotton-covered Magnet Wire 91–92
  Galvanized Telephone and Telegraph Wire 72
  Hard Drawn Copper Wire 66
  Paper Insulated Lead-covered Cables 157–159
  Signal Wires and Cables 144–145
Thirty Per Cent. Rubber-insulated Wires and Cables 141
  Weatherproof Wires and Cables 105

Page

Spider Wire, Telephone 131
Square Magnet Wire 90
Stage Cables, Theater or 133
Steel Armor Wire for Cables 81
Steel, Physical Properties of Siemens Martin 14
Steel, Iron and 39–42
Steel and Iron Telephone and Telegraph Wire 71–74
Steel Strand, Extra High Strength 76–78
  High Strength 76–78
  Siemens Martin 76–78
  Special Extra Galvanized 76
  Standard 75
Strand 27–35
  Clamp, Three-bolt 79
  Compound 32
  Concentric 27
  Extra High Strength Steel 76–78
  High Strength Steel 76–78
  Messenger 76
  Resistance of Copper 32
  Rope 32–35
  Siemens Martin Steel 76–78
  Special Extra Galvanized 76–78
  Standard Steel 75
  Tables 30–31
Stringing Wire from Coils 46
Submarine Cables 164
Sub-station Telephone Wire 129

Tables, Wiring 24–31
Telegraph and Telephone Wire, Copper, Hard Drawn 64
  Iron and Steel 71–74
Telephone Cables 130
Telephone and Telegraph Pole Data 74
Telephone and Telegraph Wire, Extra Galvanized W. & M. 71–74
Telephone and Telegraph Wire, Properties of 73–74
Telephone Rubber-covered Iron Cables 130
Telephone Wire, Copper, Bridle 129
  Drop 131
  Globe Insulated 128
  Inside 129
  Jumper 131
  Outside Distributing 128
  Pot Head 129
  Spider 131

Page

Telephone Wire—*Continued*
- Sub-station 129

Temperature Coefficients . . . 14–15
Temperature Effects on Resistance 15–18
Tensile Strength of Steel 14
Tensile Strength of Copper Wire . 14, 26
Three-bolt Strand Clamp 79
Tico Resistance Wire 80
Tinned Copper Wire Advances . . 64
Tinning and Galvanizing Wire . . 44
Theater and Stage Cables 133
Thirty Per Cent. Rubber-insulated Wires and Cables 140–145
Thirty Per Cent. Rubber-insulated Wire Specifications 141
Transmission Lines, Lightning Protection for 77
Transmission Lines, Long Span . . 77
Trolley Wire, Catenary Method of Supporting 77
- Construction Notes 60–63
- Copper 58–63
- Dimensions of 59
- Pole Data 60–63
- Specifications for 59

Underground Cables, Installation of 166–181

Page

Varnished Cambric Cables . . . 163
Vulcanizing Rubber 119

Weatherproof Coils of Wire . . . 102
- Insulation 99
- Iron Wire 102–103

Weatherproof and Slow Burning Wire, Special 105–106
Weatherproof White Finish Wires . 106
Weatherproof Wires and Cables, Reliance 98–105
Weight of Copper Wire . . . 14, 26
Weight per Mile-ohm 14, 19
Weights, Rubber-covered Wires and Cables 146
White Finish Wires, Weatherproof . 106
Wire, Bare, and Cables . . . 58–82
Wire Drawing 42–43
Wire Gauges 21–22
Wire, Manufacture of 35–44
Wire Rope 75–78
Wire Rope Clip, Crosby 79
Wires and Cables, Lead Encased . 148–166
Wires and Cables, Signal . . . 143–145
Wiring Formulæ 22–23
Wiring Tables 24–31

Index to Electric Lighting Material

Crown Rubber-covered Wires and Cables 134–138
Globe Rubber-covered Wires and Cables 125–133
Lamp Cord 108–110
Paper-insulated, Lead Encased Cables 156–162
Rubber-insulated, Lead Encased Cables 150–154
Slow Burning Wires and Cables . 104–105
Submarine Cables 164
Varnished Cambric Cables 163
Weatherproof Wires and Cables . 98–103

Index to Electric Railway Material

Armature Binding Wire 80
Bare Copper Wires and Cables . 64–65
Car Cables 138
Crown Rubber-insulated Wires and Cables 133–138
Globe Rubber-insulated Wires and Cables 125–127
Lamp Cord 108–110
Magnet Wire 85–91
Paper-insulated, Lead Encased Cables 150–154
Pole Steps 81
Rail Bonds 67–70
Resistance Wire 80
Rubber-insulated, Lead Encased Cables 150–154
Slow Burning Wires and Cables 104–105
Specifications for Hard Drawn Copper 66

Page

Galvanized Telephone and Telegraph Wire 71–74
Steel Strand 75–76
Strand Clips, Galvanized 79
Submarine Cables 164

Page

Thirty Per Cent. Rubber-insulated Wires and Cables 140–143
Trolley Wire 58–63
Weatherproof Wires and Cables . 98–103

Index to Telephone and Telegraph Material

Bare Copper Telephone and Telegraph Wire 64
Bare Galvanized Telephone and Telegraph Wire 71–74
Globe Insulated Telephone and Telegraph Wires and Cables . . 128–131
  Bridle Wire 129
  Drop Wire 131
  Inside Wire 129
  Jumper Wire 131
  Outside Distributing Wire . . . 128
  Pot Head Wire 129
  Spider Wire 131
  Sub-station 129
  Telegraph Cables 130
Pole Steps 81

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